MILITARY SKETCHING

AND

MAP READING

FOR

NON-COMMISSIONED OFFICERS

GRIEVES

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AND

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FOR

NON-COMMISSIONED OFFICERS

(Illustrated)

BY

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30th Infantry

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PREFACE

This book was written to fulfill the following urgent requirements:

1. A textbook of Military Sketching and Map Reading within the comprehension of the average non-commissioned officer of the Mobile Land Forces.

2. A textbook which will relieve organization commanders of devising a new course each year and which will standardize the instruction and furnish a uniform basis for the prescribed tests by battalion commanders and inspectors.

3. A textbook in which Military Sketching and Map Reading go hand in hand, each being an amplification of the other.

4. A textbook in lesson form, each lesson being carefully planned as to the amount and proper sequence of its subject matter, and the number of lessons being such that the course may be completed within the time usually available for this subject in the Garrison School Course for Non-Commissioned Officers.

The author bases his knowledge of the capacity of the average non-commissioned officer upon observations made during three years in which he was engaged on duty in connection with the Progressive Military Map of the United States and the Philippine Islands, four years in which he instructed the non-commissioned officers of the companies to which he was assigned, and during the past two years as Officer in Charge of Map Section, Military Information Division, Manila, P. I. While on duty in connection with the Progressive Military Map he was assisted by enlisted men form the various branches of the Mobile Army, and since being on duty in the Military Information Division, it has been one of his routine duties to review the vast number of sketches turned in to be filed.

In view of the above observations, it is believed that a knowledge of the subject matter of this book should be readily acquired by the average non-commissioned officer.

INTRODUCTION

General Principles

This text treats of that portion of Military Topography included in the subjects of Military Topographical Sketching and Military Map Reading.

Military Topographical Sketching treats of Military Road and Area Sketches and methods involved, while Military Map Reading pertains to the correct interpretation of all features represented on these sketches.

The two subjects, in so far as they are treated in this text, may be called the "Married Pair," they go hand in hand. In order to efficiently perform the duties pertaining to the office, it is absolutely essential that every non-commissioned officer possess a working knowledge of both subjects.

This text makes no distinct division of its course of instruction in Military Sketching and Map Reading; as one is taught, the other is learned; the latter proves the former.

The average non-commissioned officer, after a conscientious study of the following thirty lessons should be able to construct a road or an area sketch, and should possess a knowledge of Military Map Reading sufficient to enable him to readily interpret any topographical military map.

Before entering upon this course, the instructor should secure a sufficient amount of the following articles to supply the class: pencils, (Faber's HHHH, HHHHHH and HB), erasers, profile paper, tracing paper, and the best available military maps of the surrounding country. Each member of the class should be equipped with a compass. See Appendix for the construction of drawing-board with tripod and attachment for reading angles of slope. The Universal Rule for Military Sketching and Map Reading fulfills all other needs of the student of this subject such as working and reading scales, scales of map distances, protractor, means of drawing perpendicular and parallel lines, rates of speed per minute of various arms of the service, an easy method of solving all visibility problems, memorandum pad and message blank. The Universal Rule is furnished with each copy of this book.

The instructor should anticipate the requirements of each lesson and have the necessary paraphernalia on hand, for example, the drawing-boards and tripods should be completed before Lesson IV, the attachments for reading angles of slope should be completed before Lesson XIII and the Model of Map A and sand-table should be constructed before Lesson IX.

Finally, the instructor should bear in mind that his class will not obtain the desired results of this course without his enthusiastic and intelligent co-operation.

LESSON I

Importance of Military Sketching and Map Reading

It is said that one-half of the people who read a book never read the preface nor the introduction. Before starting on this course, a part of the first lesson should be devoted to carefully reading the preface and introduction, this to enable the student to gain an idea of the scope of the course which he is about to study, also that instructor and student may each know what is expected of the other.

In order to render his country efficient service in time of need, it is absolutely necessary that every non-commissioned officer be able to construct a road and an area sketch, and that he be able to read a military topographical map. You are sent to a certain point to observe and report. In no way other than by making a sketch can you properly convey to your commanding officer what you have seen.

In order to demonstrate the urgent necessity of a knowledge of military sketching, the instructor should take the class to a point possessing a good view of country covered with a variety of natural and artificial ground features. After studying the landscape for ten or fifteen minutes, members of the class will face away from the country just observed and make a written report of what they have seen: locations and directions of hills, valleys, rivers, roads, railroads, telephone and telegraph lines, locations and dimensions of bridges, buildings, etc.

The instructor will then verify these reports in the presence of the class, noting all errors and omissions. This will serve as an object lesson of the importance of a knowledge of Military Sketching.

Let us imagine two non-commissioned officers, equally brave and alert, possessing equal military qualifications with the exception that one is able to read a map accurately and the other knows nothing of this important military accomplishment. These men are sent out with detachments on similar important missions in time of war. They are both brave, both alert, but one is absolutely sure of the road or trail that he is taking, while the other, unfortunately, is not; he has misgivings, he begins to lose confidence in himself and his men lose confidence in him. Brave as he is, the element of uncertainty prevails, he loses assurance and likewise the trail, and leads his detachment to disaster. The other man is positive, retains his bravery and the respect and confidence of his men and leads them to success.

The main object of this lesson is to instill in the mind of each member of the class that to be a leader and give the best service to his country he must acquire a working knowledge of Military Sketching and Map Reading.

LESSON II

Length of Pace and Scales of Paces

Each member of the class, in order to determine the length of his pace, should pace some known course near his station, as for example, a thousand yards on the target range.

While pacing one should walk at an easy, natural and uniform gait. This is important as there is always a tendency for the beginner to consider pacing and his ordinary gait as entirely distinct which usually results in his first scale of paces being too long. This may be obviated by pacing a sufficiently long course several times, first impressing upon the student's mind the necessity of taking a perfectly natural and uniform gait.

Each man will pace the course four times. Suppose that his four results of pacing a course 1000 yards long are:

	1118 paces.
	1109 "
	1120 "
	1117 "
Total	4464 paces.

$4464 \div 4 = 1116$ paces (average number of his paces for 1000 yards).

To determine the length of his pace in inches:

1000 yards = 36000 inches.

$36000 \div 1116 = 32.2$ inches, the length of his pace.

Having determined the length of pace let us now consider the subject of scales of maps. It is very clear that the ground and all of the objects upon it cannot be represented as large on the map as they actually are. They must be reduced in size. In other words, any distance on the map is a certain fixed part of the corresponding distance on the ground, and this relation between map distance and ground distance is called the scale of the map.

The scale should be no larger than is necessary to bring out all of the required details. For example, it has been found that the scale 3 inches = 1 mile, (meaning that 3 inches on the map represents one mile on the ground), is the proper scale for road sketches. It gives just enough room to insert all of the details of military importance, while, if we were to use the scale 1 inch = 1 mile for road sketches, there would not be enough room, and by using the scale 6 inches = one mile we would burden ourselves and those reading the map with an unnecessary amount of paper.

There are three ways in which the scales of maps may be represented:

1st. A plain statement, as for example, 3 inches = 1 mile.

2nd. Represented by a fraction. To determine the fraction representing any scale, as 3 inches = 1 mile, let the map distance be the numerator and the ground distance the denominator, both terms of the fraction being of the same denomination, then reduce the fraction so that the numerator will be unity, as for example:

$$\frac{\text{3 inches on map}}{\text{1 mile on ground}} = \frac{\text{3 inches}}{\text{63360 inches}} = \frac{1}{21120} = \text{Representative Fraction (abbreviated R. F.).}$$

3rd. Graphically, in which the scale is actually represented on the map or on a ruler by a line divided into equal parts, each division being marked by the distance which it represents on the ground.

There are two kinds of graphical scales: one for making the map, called the working scale, and one for reading the map, called the reading scale. If the same units of measure were used for both map making and map reading, one scale would answer for both purposes, but this is seldom the case as we may obtain our distance in terms of paces or strides of various lengths depending upon the individual, while the party reading the map necessarily must have the distance expressed in terms of well known units as yards or miles.

In order to be able to make a map or read a map we must have in our possession the proper working and reading scales. With each copy of this book is a Universal Rule for Military Sketching and Map Reading. On this rule are blank spaces to inscribe one inch, three inch and six inch scales of paces. Figs. I and II show scales for different lengths of paces or strides. Any desired scale may be copied from these plates by placing the edge of the Universal Rule on the proper line or by interpolating between the lines.

After each man has determined the length of his pace the following scales:

1 inch = 1 mile.
3 inches = 1 "
6 inches = 1 "

should be inscribed on his Universal Rule as indicated above. Small grooves should be made with a sharp knife to indicate the divisions of the scale, and these grooves marked with black, water-proof, India ink, using a crow-quill pen.

Either the instructor or some member of the class who is a fair draftsman should inscribe the scales on the rules. When the scales are once transferred to the rules, these rules should be considered just as much a part of the non-commissioned officer's equipment as his canteen.

On the Universal Rule are reading scales of yards for one, two and three inches equals one mile. By the aid of these scales and multiples thereof, a reading scale in yards for any map may be quickly constructed.

For a method in detail of constructing scales see appendix. However, the mathematical amd mechanical work involved in constructing scales is no more essential to the instruction of non-commissioned officers than the construction of a compass.

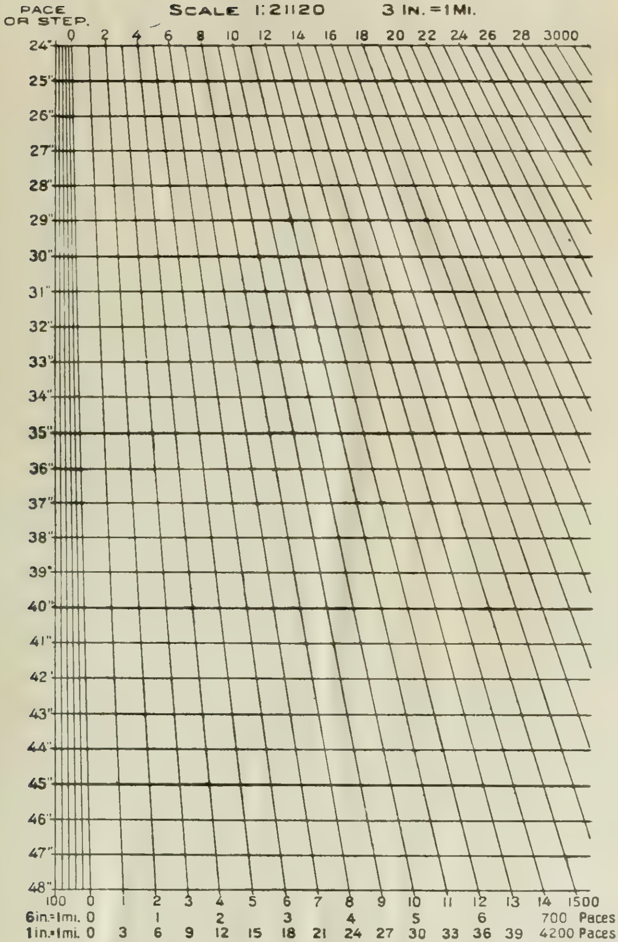

PACE OR STEP.
SCALE 1:21120 3 IN. = 1 MI.
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 3000
24" 25" 26" 27" 28" 29" 30" 31" 32" 33" 34" 35" 36" 37" 38" 39" 40" 41" 42" 43" 44" 45" 46" 47" 48"
100 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 1500
6in.=1mi. 0 1 2 3 4 5 6 700 Paces
1in.=1mi. 0 3 6 9 12 15 18 21 24 27 30 33 36 39 4200 Paces

Fig. 1

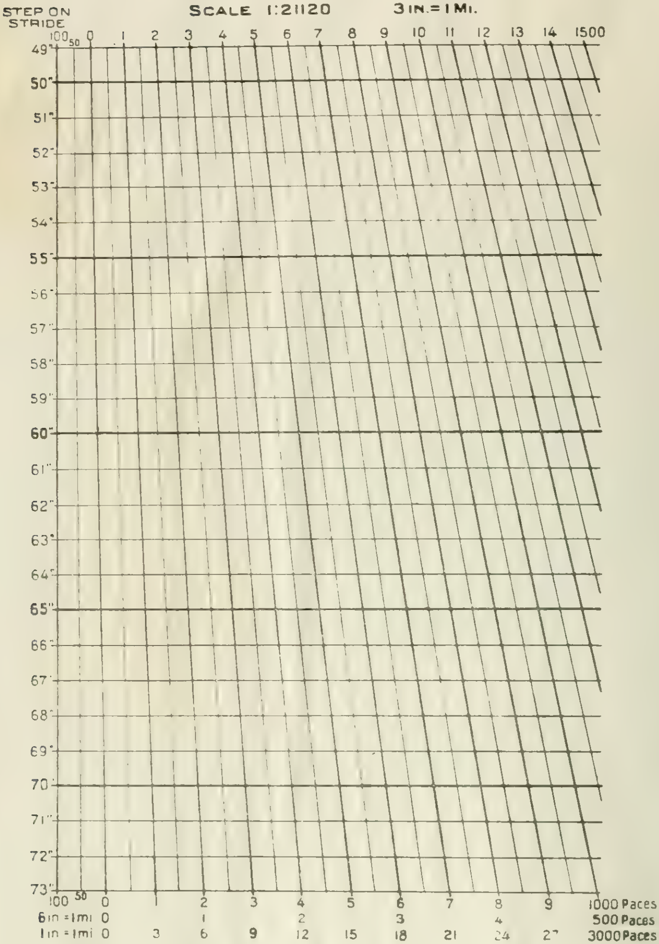

STEP ON STRIDE
SCALE 1:21120
3 IN. = 1 MI.
100 50 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 1500
49"
50"
51"
52"
53"
54"
55"
56"
57"
58"
59"
60"
61"
62"
63"
64"
65"
66"
67"
68"
69"
70"
71"
72"
73"
100 50 0 1 2 3 4 5 6 7 8 9 1000 Paces
6 in = 1 mi 0 1 2 3 4 500 Paces
1 in = 1 mi 0 3 6 9 12 15 18 21 24 27 3000 Paces

Fig. 2

LESSON III

The Compass and Declination of the Needle

Having determined a means of representing the map distance between two objects on the ground, it now follows that we must learn how to represent the direction of one object from another.

We are able to do this by means of the magnetic compass, an instrument having a light needle which swings freely and comes to rest with its north end always pointing to what is known as the magnetic north. The magnetic north differs from the true north in many localities, and moreover this discrepancy is constantly changing, and for this reason maps should always have the true as well as the magnetic north indicated. The number of degrees that the needle points away from the true north is called the DECLINATION OF THE NEEDLE.

For accurate measurement of directions, the circle described by the point of the compass needle is divided into 360 equal parts called degrees. (See Fig. 3.)

There are a few simple methods of determining the true meridian (true north-and-south line) with a degree of accuracy sufficient for military sketching and map reading:

1st.—By means of the North Star. Without instruments, it can be determined approximately by placing two cords, with weights attached, in line with the Star. The cords should be twelve feet apart, and to see the forward one, it will be necessary to throw a light upon it. This line can readily be prolonged by daylight.

2nd.—By aid of the sun and plumb-bob (see Fig. 4). On a level piece of ground lean a pole toward the North, and rest it in a crotch made by two sticks as shown. Suspend a weight from the end of the pole so that it nearly touches the ground; then, about an hour before noon, attach a string to a peg driven directly under the weight, and, with a sharpened stick attached to the other end of the string, describe an arc with a radius equal to the distance from the peg to the shadow of the tip of the pole. Drive a peg on the arc where the shadow of the tip of the pole rested. About an hour after noon, watch the shadow on the tip as it approaches the eastern side of the arc, and drive another peg at the point where it crosses. By means of a tape or string find the middle point of the straight line joining the last two pegs mentioned. A straight line joining this middle point and the peg under the weight will be in the true meridian.

Place a pole about 100 yards in prolongation of this line, and with the compass sight back on the tip of the inclined pole, and the declination will be obtained.

3rd.—By aid of the watch and sun. Lay the watch on some level surface, and revolve it until the hour hand points directly under the sun. Then by reference to the divisions on the dial, determine the point on it midway between the hour hand

and Fig. XII. A line through this point and the pivot of the hands will be approximately in the true meridian (see Fig. 5).

The operation of pointing the hour hand directly under the sun is made easy by casting the shadow of a vertical straw or straight stick across the face of the watch and then bringing the hour hand into this shadow.

The watch method will not answer during certain seasons in the Tropics when the sun passes directly overhead.

There is also another slight error due to the fact that in some sections there is a difference of a half hour between Standard and Sun time.

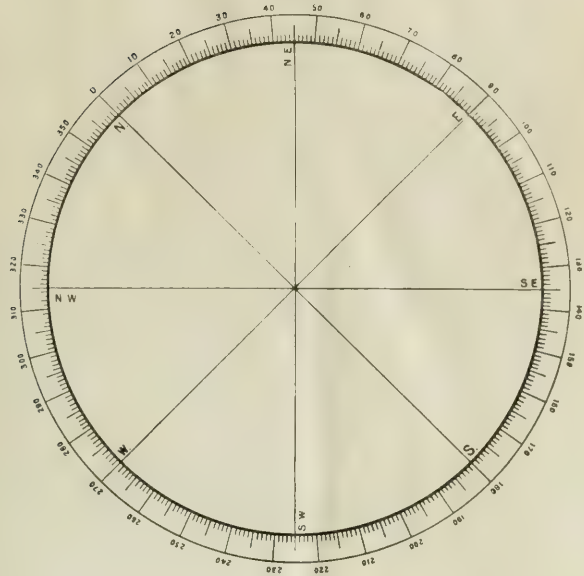
The class will obtain the declination of the needle for its particular locality by all of the above methods and compare results.

After consulting Fig. 3, each man should be required to draw on the black-board angles of various degrees.

Imagine that you are at the center of the circle, Fig. 3. Determine the following directions:

N 30° E.
S 15° W.
E 30° N.
W 15° N.

In order to take up the work assigned in the following lesson, each sketcher should be equipped with a compass, drawing-board (see Appendix for construction drawing-board with tripod and attachment for reading slopes), universal rule, rubber eraser, pocket knife, paper. Faber H or HB pencil and a half dozen thumb tacks.



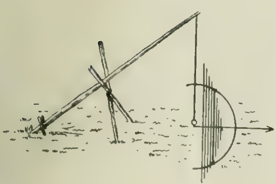


Fig. 4

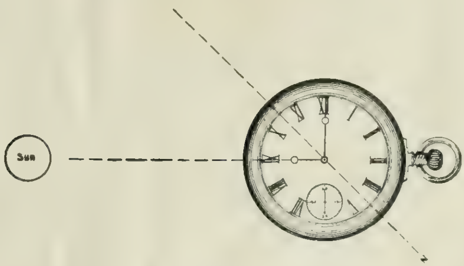


Fig. 5

LESSON IV

Distances and Directions

Fig. 6 represents the road A B C D to be sketched.

On your paper draw a straight line representing the needle of the compass. Mark one end of this line, N.

In sketching, always hold your drawing-board in such a position that the north end of the compass needle and the arrow end of the needle indicated on the paper are pointing in the same direction. (In the future we will refer to this operation as "Orienting the board.")

Go to the point A of the road. (See Fig. 7.) Orient the board. From any convenient point (a) (one usually knows the general direction of the course to be sketched and should select a point of beginning which will afford the greatest use of the paper. For example, if your course takes you in an easterly direction, your point of beginning should be near the west margin of the paper), on the board draw a light straight line in the direction A b. Next pace the distance A to B, and with your scale of paces (3 inches = 1 mile) lay off the line a b representing the distance A B.

The paces may be counted or a pedometer may be used. In order to avoid error in counting paces a check mark should be made of each 100 paces.

The pedometer is a small instrument about the size and form of a watch used for recording the number of steps taken in walking. By means of a small weighted lever which descends with every step, motion is communicated to a train of wheels and the number of steps is recorded on a dial by pointers.

Next orient the board at B, draw a straight line in the direction B C, pace B C and lay off the line b c.

Orient the board at C, draw a light line in the direction C D, pace C D and lay off the line c d.

The instructor will require each member of the class to plot a course having several changes of direction. If the drawing-board is placed on a tripod it will greatly assist the beginner in determining an accurate line of sight. The scale 6 inches = 1 mile might be used instead of the 3-inch scale, thus making more evident all errors in distance and direction.

On returning to barracks, results will be compared and errors pointed out. An accurate sketch of the route taken should be drawn upon the black-board in order that each man's sketch may be compared with it.

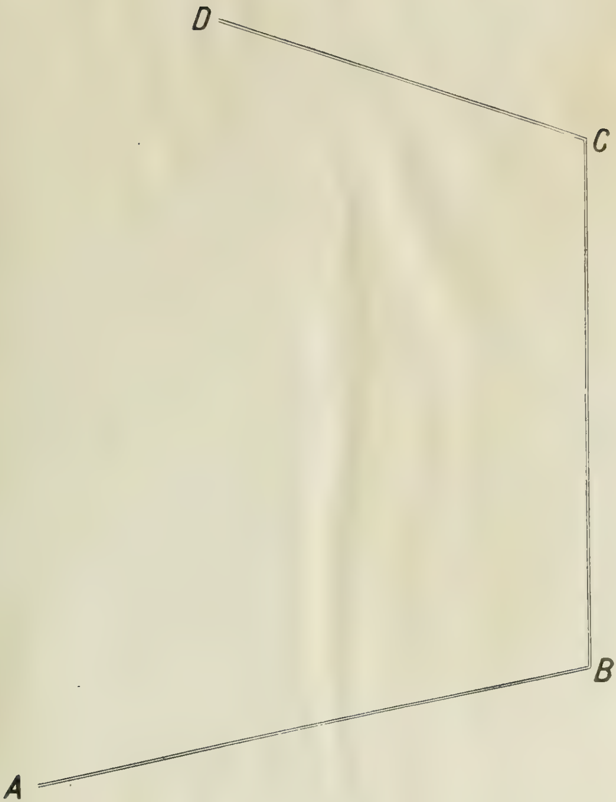


Fig. 6

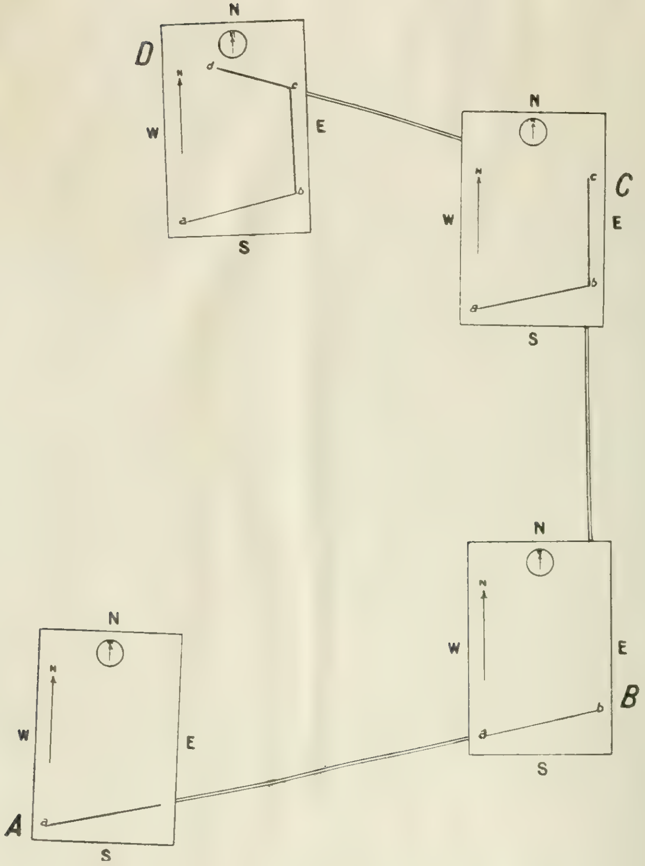


Fig. 7

LESSON V

Distances and Directions, Continued—Location of Points by Intersection and Resection—Practical Method of Representing Ground Features

For this lesson some course in which the point of beginning and ending are the same should be designated, as for example, the course A B C D E F A—Fig. 8. This will serve as an excellent check upon the work. The methods employed will be the same as in the last lesson except that important points to the right or left of the course should be located by intersection and locations along the course may be verified by resection.

To locate a point by intersection, as for example the hill, G, Fig. 8.—Orient the board at A, Fig. 9, mark the point (a) on the board to correspond to A on the ground. Sight in the direction B, and from (a) draw a straight line in the direction of B, then sight at the hill G, and draw a straight line from (a) in the direction of G. (Care must be exercised to keep the board constantly oriented. In determining the line of sight from the point of observation on the map to some distant point on the ground, pivot the universal rule at the point of observation and sight along the upper edge of the rule toward the object keeping the rule perpendicular to the board.) Pace the distance A B, orient the board at B, and lay off the map distance (ab) corresponding to the ground distance A B, then sight at the hill G and draw a straight line from (b) in the direction of G. The lines drawn from (a) toward G and from (b) toward G intersect at (g) which is the map location of the hill G. In a similar manner any other points as G, H, and I (Fig. 8) may be located by intersection from any two points.

Angles of less than 30 degrees or greater than 120 degrees at the point of intersection should be avoided as the two intersecting lines are so nearly parallel that it is difficult to locate the exact point of intersection.

To locate a point by resection:

Suppose that at the point F of the course A B C D E F A, Fig. 8, you wish to verify your location. The points G and A on the ground have already been correctly located on the map at (g) and (a), (see Fig. 10). The sketcher is at the point F which he wishes to locate on his map. He orients the board with the compass, pivots the rule at (g) and at the same time sighting the hill G, and draws a line along the rule toward his body. Similarly pivot the rule at (a), sighting A, and drawing a line along the rule toward his body it cuts the line G g. The intersection of the lines at (f) is the sketcher's map location.

As the sketcher passes over the course he should note in writing on his sketch such ground features as bridges, fords, ferries, houses, woods, cultivated fields, villages, high hills, streams or any other information of importance. (See Fig. 8.)

When completed the following information should be indicated at some convenient place on the sketch: (See Fig. 8.)

1. Location of sketch.
2. Name and organization of sketcher.
3. Date of sketch.
4. Scale of map.
5. The magnetic north, and, if the declination of the needle is known, the true north should be indicated also.
6. Reading scale.
7. Contour interval.
8. Scale of Map Distances.

7 and 8 need not be indicated unless the sketch is contoured. The subject of contouring will be taken up in a later lesson.


To Brownsville
School House
F.
E.
Woods
No bridge
Fordable 2 ft.
I High Hill
Wood bridge
Woods
House
Woods
Woods
A.
Cultivated
G High Hill
H. High Hill
Cultivated
Cultivated
D.
Greenville
River
House
Stonebridge
To Smith ville
B.
C.
Green
Cultivated
Woods
Woods
True North
Magnetic North
3°30'
SKETCH OF COUNTRY NORTH-WEST
OF GREENVILLE
By Sgt. James Brown, Co. D, 24th Inf.
Scale 3 inches = 1 mile
0
1/4
1/2
3/4
1 mile

Fig. 8

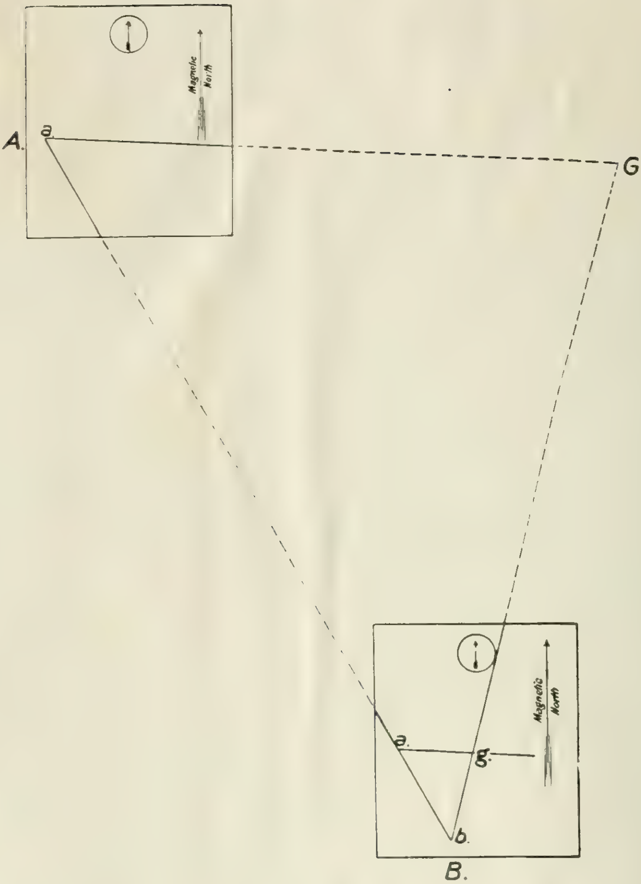


Fig. 9

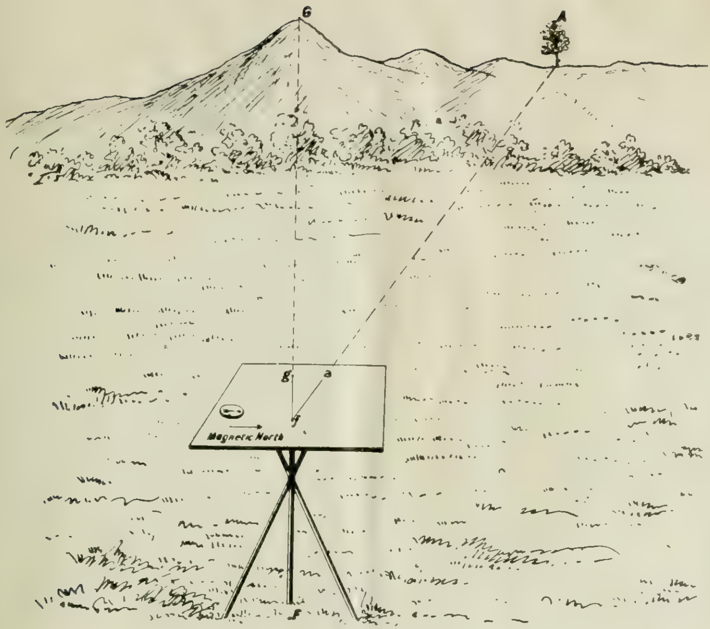


Fig. 10

LESSON VI

Conventional Signs

Having learned how to represent ground distances and directions on the map, we will now consider the many natural and artificial ground features of importance and the method of representing them on the map.

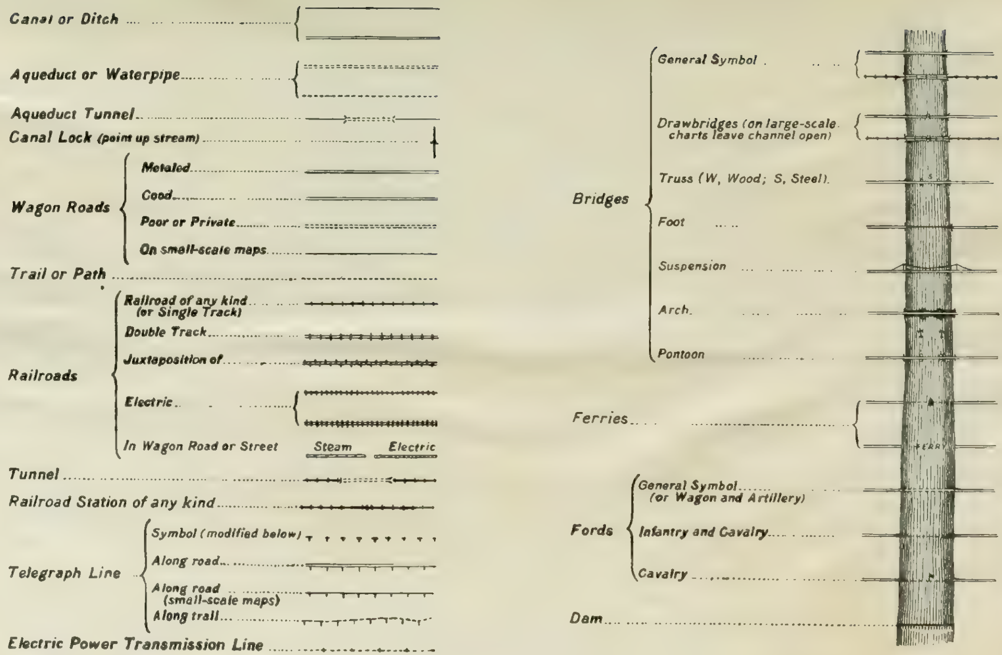
In order that all may be able to read the map when completed, we must have some fixed method of representing these ground features. With this in view the United States Geographic Board adopted, in 1912, a system of Conventional Signs for the use of all map making departments of the government. At the close of the lesson are those that pertain to the work to be covered by this book. Members of the class will be required to reproduce these signs as neatly as possible and this lesson will be devoted to that purpose.

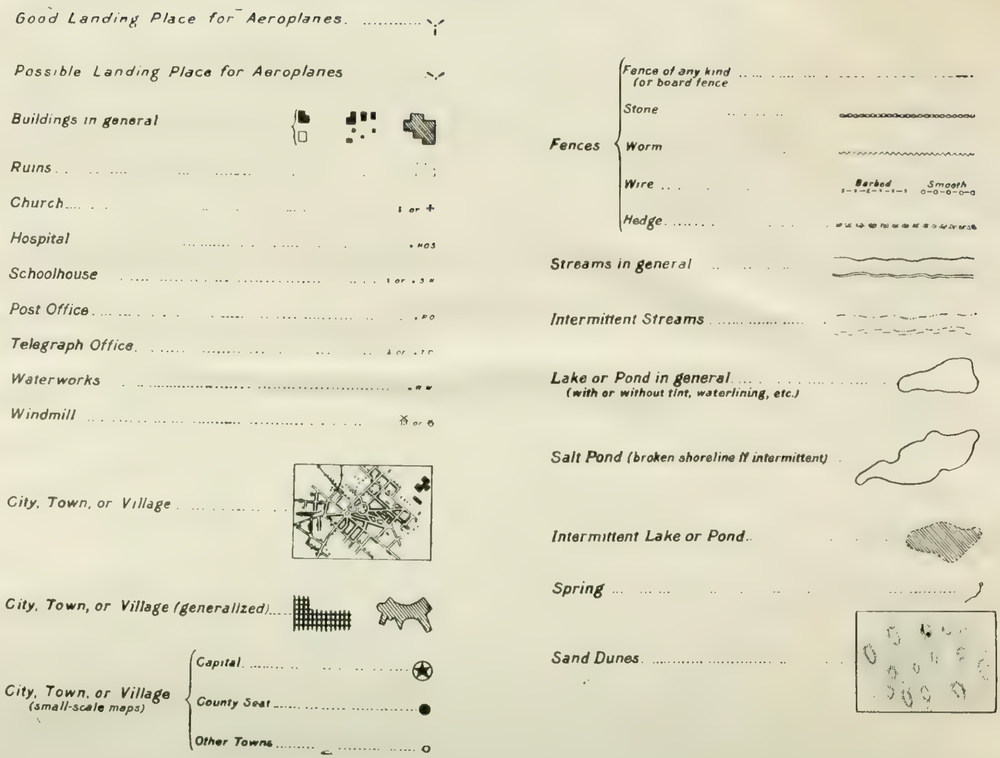
The instructor should superintend and criticise the work, especially should he avoid the usual tendency of making the signs too large. The ability to neatly reproduce these conventional signs should be included in the examination over this subject. When you find some idle moments with pencil and paper at hand, your time may be profitably employed by practicing the construction of conventional signs.

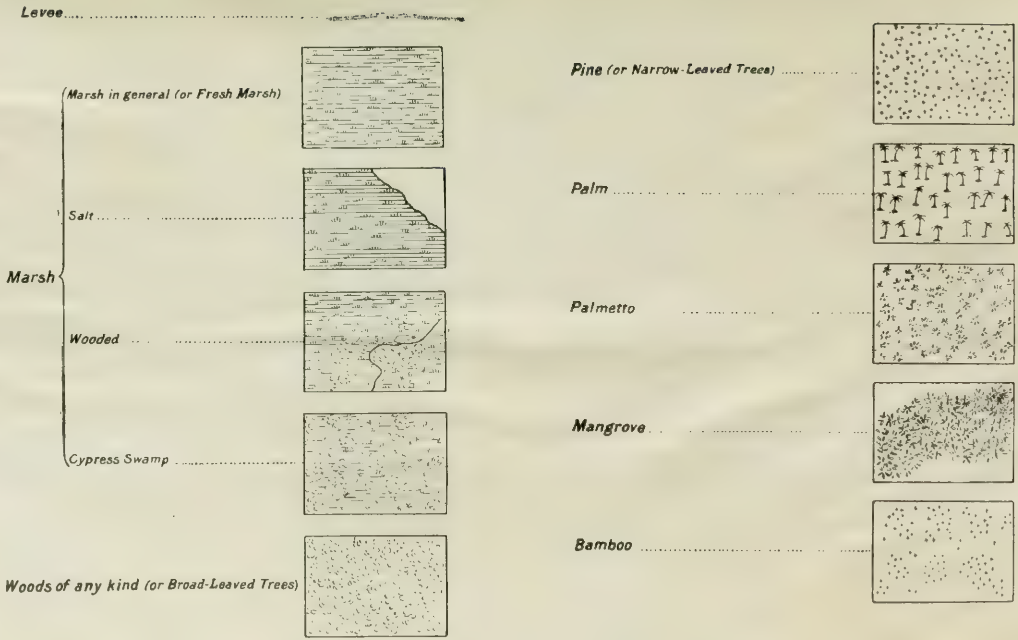
Just a few words about pencils would not be amiss at this particular point.

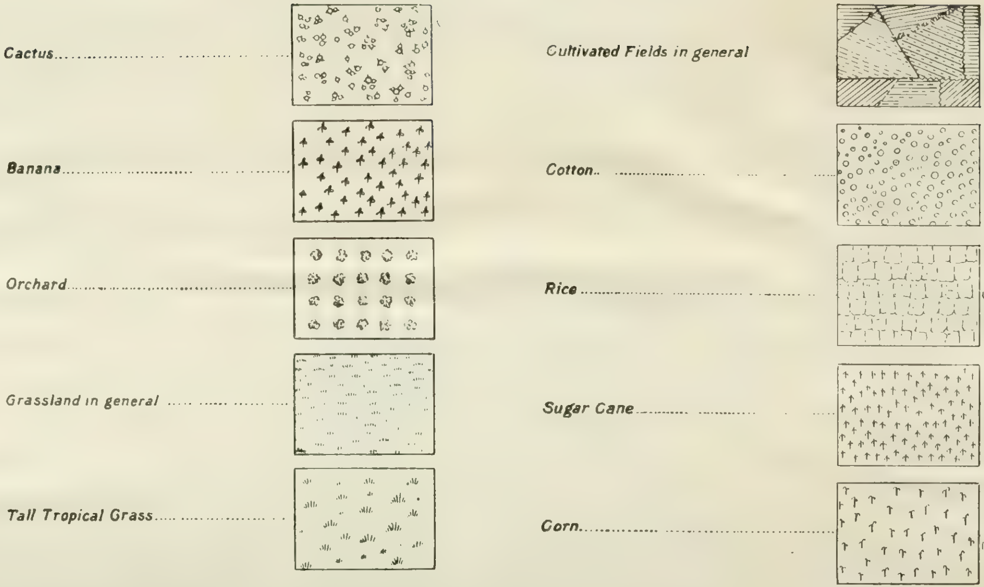
The best for plotting are the hard kinds corresponding to Faber's Siberian HHHH and HHHHHH, especially for drawing fine lines and making points. For most kinds of work, a sharp-pointed pencil is used. For drawing long straight lines, a chisel-pointed pencil should be used to produce a line of uniform breadth. For sketching and filling in conventional signs, softer pencils are preferable, such as correspond to Faber's HB or H. To keep the point always in good condition one should have a piece of fine sand-paper at hand for that purpose, being careful to remove any lead dust from the point before using. Much more depends upon the proper sharpening of a pencil and afterwards keeping it so, than is commonly supposed.

Most drawings to be inked are first constructed in pencil, the lines being made with as little pressure and as fine as is possible to show distinctly.


Canal or Ditch
Aqueduct or Waterpipe
Aqueduct Tunnel
Canal Lock (point up stream)
Wagon Roads
Metaled
Good
Poor or Private
On small-scale maps
Trail or Path
Railroads
Railroad of any kind (or Single Track)
Double Track
Juxtaposition of
Electric
In Wagon Road or Street
Steam
Electric
Tunnel
Railroad Station of any kind
Telegraph Line
Symbol (modified below)
Along road
Along road (small-scale maps)
Along trail
Electric Power Transmission Line
Bridges
General Symbol
Drawbridges (on large-scale charts leave channel open)
Truss (W, Wood; S, Steel).
Foot
Suspension
Arch.
Pontoon
Ferries
Fords
General Symbol (or Wagon and Artillery)
Infantry and Cavalry
Cavalry
Dam

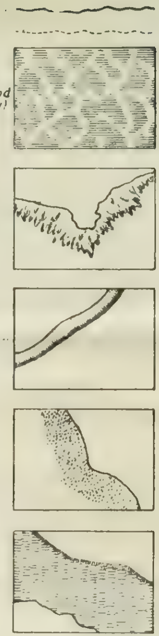

Good Landing Place for Aeroplanes
Possible Landing Place for Aeroplanes
Buildings in general
Ruins
Church
or
Hospital
Schoolhouse
Post Office
Telegraph Office
Waterworks
Windmill
or
City, Town, or Village
City, Town, or Village (generalized)
City, Town, or Village
(small-scale maps)
Capital
County Seat
Other Towns
Fences
Fence of any kind
(or board fence
Stone
Worm
Wire
Barbed
Smooth
Hedge
Streams in general
Intermittent Streams
Lake or Pond in general
(with or without tint, waterlining, etc.)
Salt Pond (broken shoreline if intermittent)
Intermittent Lake or Pond
Spring
Sand Dunes


Levee
Marsh
Marsh in general (or Fresh Marsh)
Salt
Wooded
Cypress Swamp
Woods of any kind (or Broad-Leaved Trees)
Pine (or Narrow-Leaved Trees)
Palm
Palmetto
Mangrove
Bamboo


Cultivated Fields in general
Cotton
Rice
Sugar Cane
Corn
Cactus
Banana
Orchard
Grassland in general
Tall Tropical Grass

Shorelines — Surveyed / Unsurveyed

Shores and Low-Water Lines — Tidal Flats of any kind (or as shown below) / Rocky Ledges / Sand / Gravel and Rocks / Mud



Regimental Headquarters

Brigade Headquarters

Division Headquarters

Corps Headquarters

Infantry in line

Infantry in column

Cavalry in line

Cavalry in column

Mounted Infantry

Artillery

Sentry

Vidette

Picket, Cavalry and Infantry

Support, Cavalry and Infantry

Wagon Train

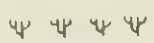
Adjutant General

Quartermaster

Commissary

Medical Corps	
Ordnance	
Signal Corps	
Engineer Corps	
Gun Battery	
Mortar Battery	
Fort } True plan to be shown if known	
Redoubt } True plan to be shown if known	
Camp	
Battle	
Trench	

When color is used execute the following in red

Abattis	
Wire Entanglement	
Palisades	
Contact mines	
Controlled mines	
Demolitions	

AUTHORIZED ABBREVIATIONS

A.	Arroyo	L.S.S	Life Saving Station
abut	Abutment	L.H	Lighthouse
A	Arch	Long.	Longitude
b	Brick	Mt	Mountain
B S.	Blacksmith Shop	Mts	Mountains
bot	Bottom	N	North
Br	Branch	n f	Not fordable
br	Bridge	p	Pier
C	Cape	pl.	Plank
cem	Cemetery	P O	Post Office
con	Concrete	Pt	Point
cov	Covered	q p	Queen-post
Cr	Creek	R	River
cul	Culvert	R H	Roundhouse
D S	Drug Store	R R	Railroad
E	East	S	South
Est	Estuary	s	Steel
f.	Fordable	S H	School House
Ft.	Fort	S M	Saw Mill
G S	General Store	Sta	Station
gir	Girder	st	Stone
G. M.	Grist Mill	str	Stream
i	Iron	T G	Toll Gate
I	Island	Tres	Trestle
Jc	Junction	tr	Truss
k.p.	King-post	W. T.	Water Tank
L	Lake	W. W.	Waterworks
Lat	Latitude	W.	West
Ldg	Landing	w.	Wood

LESSON VII

Conventional Signs, Continued

Fig. 11 represents the same area as Fig. 8 in Lesson V except that the natural and artificial ground features have all been represented by the proper conventional signs.

Each man will pass over some designated course, plotting distances and directions and sketching in all details of military importance using the conventional signs as indicated in Fig. 11. A little work of this kind will greatly assist the student in map reading. After he has become familiar with the conventional signs, it will be found more practicable in many cases in military sketching, especially in doing the field work, simply to write the words in their proper location as in Fig. 8, rather than to insert the conventional signs, while in other cases it may involve less labor to use the signs, as for example, streams, roads, trails, bridges, rail-roads, buildings, etc., are much more conveniently represented by the conventional signs than by any other method, while in the case of woods, cultivated fields, various classes of vegetation and like details it is without doubt much quicker and just as accurate to write the words: woods, corn, meadow, etc., indicating their extent by a light line encircling the area.

In general, one may follow the rule that the best field method to adopt is the quickest and most accurate one that will convey to the mind of another exactly what you have observed, then if time permits and conditions are suitable the sketch may be traced representing all ground features by the proper conventional signs.

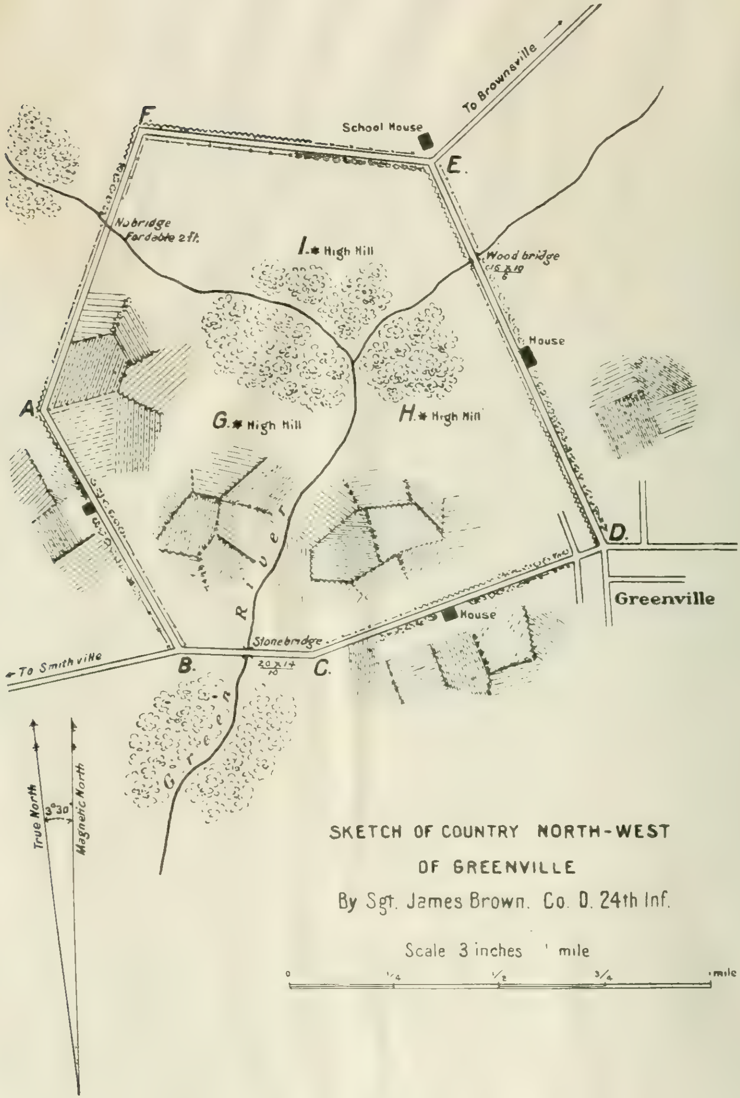

To Brownsville
School House
F.
E.
No bridge
Fordable 2 ft.
I. High Hill
Wood bridge
House
A.
G. High Hill
H. High Hill
D.
Greenville
River
House
Stonebridge
To Smithville
B.
C.
Green
True North
Magnetic North
3°30'
SKETCH OF COUNTRY NORTH-WEST
OF GREENVILLE
By Sgt. James Brown. Co. D. 24th Inf.
Scale 3 inches 1 mile
0
1/4
1/2
3/4
1 mile

Fig. 11

LESSON VIII

Distances and Directions, Continued—Map Reading

Having learned how to represent ground distances and directions on the map, we should now be able to determine from the map the distance between objects on the ground and the direction of one from another.

We will first consider converting map distance into ground distance. Every complete map has a reading scale of some well known unit as yards or miles, so all that is necessary to determine the ground distance between points on the map is to apply the reading scale to the map distance or the map distance to the reading scale.

There are several simple methods of taking distances from the map:

1st.—With the universal rule. If the scale on the map is one, two or three inches equals one mile, simply apply the universal rule and read off the distance in yards from the corresponding reading scales on the rule. If the scale on the map is four, five, six or any other whole number of inches to the mile, apply the reading scale, one inch equals one mile and divide the reading by four, five, six or whatever the number may be. Practically all military maps are made on a scale of a certain whole number of inches to the mile so that the universal rule will answer for scaling distances from the map in nearly all cases. The Geological Survey Maps made on a scale of 1-62250 are much used by the army, but as there is a difference of but about one per cent between these maps and maps made on a scale of one inch equals one mile, (1-63360), the one inch reading scale is sufficiently accurate for most purposes.

2nd.—Suppose that you have no reading scale except the one printed on the map. If such is the case, apply a piece of straight edge paper to the distance between the two points to be measured. Mark the distance on the paper and apply the paper to the reading scale of the map, or copy off the reading scale on the edge of a piece of paper and apply the paper to the map.

3rd.—A scale of inches may be applied to the distance between the two points to be measured, then multiply the number of inches between the points by the number of miles per inch given on the map. (Caution: do not confuse the terms—"miles per inch" and "inches per mile.")

It is often necessary to take off distances from the map in terms of one's paces. To do so simply apply your scale of paces for one, three or six inches equals one mile to maps of those scales and for maps of two, four, five or any other whole number not represented on your universal rule, apply your one inch scale of paces and divide the results by two, four or five as the case may be.

To Determine from the Map the Direction of One Point from Another

As the captain consults his chart and compass in guiding his ship across the ocean, so must the soldier consult his map and compass in traveling through unknown regions.

The usual style of box compass or other small compasses has the four cardinal points N. E. S. and W. (North, East, South and West), marked on its surface and circle graduated in degrees reading zero, clockwise around to 360 degrees, beginning and ending at N. In order to travel by the compass one must be able to convert map directions into compass directions. In other words we must be able to determine the MAGNETIC AZIMUTH of any line.

By the MAGNETIC AZIMUTH of a line is meant the horizontal angle that the line makes with the compass needle measuring from the north point clockwise around the circle. The TRUE AZIMUTH is measured in the same direction from the north point of the true meridian, (true north-and-south line).

Fig. 12 is an illustration of a protractor, an instrument for measuring and plotting angles. A protractor similar to the one shown in Fig. 12 is inscribed on one face of the universal rule. This protractor is so graduated that it is laid on the east side of the meridian through the plotted position for plotting angles from zero to 180 degrees; from 180 degrees to 360 degrees the protractor is placed on the west side of the meridian.

To illustrate,—you are at the point A, Fig. 13. You wish to obtain the magnetic azimuth of the line A B. Draw a line A C, through A parallel to the magnetic north-and-south line. Lay your protractor along A C, the centre of the protractor at A. (The center of the protractor is indicated by the arrow point.) Read the number of degrees between A C and A B. It is found to be 63 degrees which is the magnetic azimuth of the line A B.

Then suppose that you are at A, and wish to proceed in the direction of B. Simply hold the compass so that the needle is at N., then follow in prolongation of a line drawn through the pivot of the needle and 63 degrees. The course is kept by occasional reference to the compass which is held in front of you or placed upon the ground.

Maps of various scales should be issued to each member of the class who should determine the distances in terms of yards, miles or his paces, and the magnetic azimuth between designated points in accordance with instructions given in this lesson.

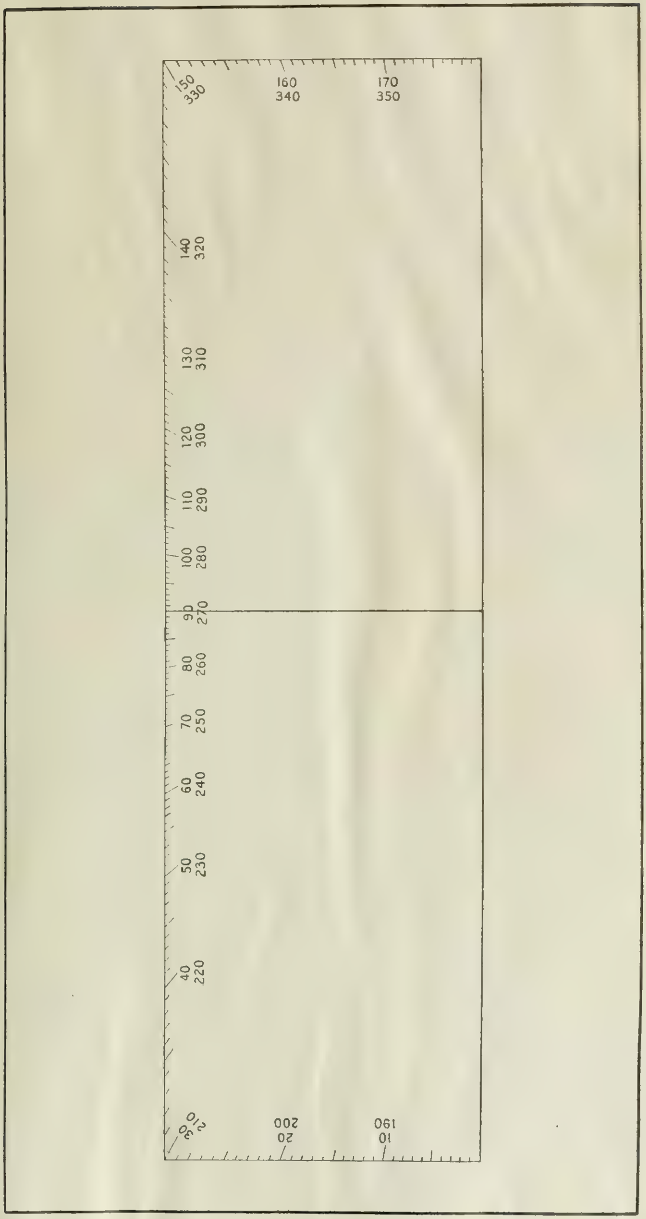

150 330
160 340
170 350
140 320
130 310
120 300
110 290
100 280
90 270
80 260
70 250
60 240
50 230
40 220
30 210
20 200
10 190

Fig 12

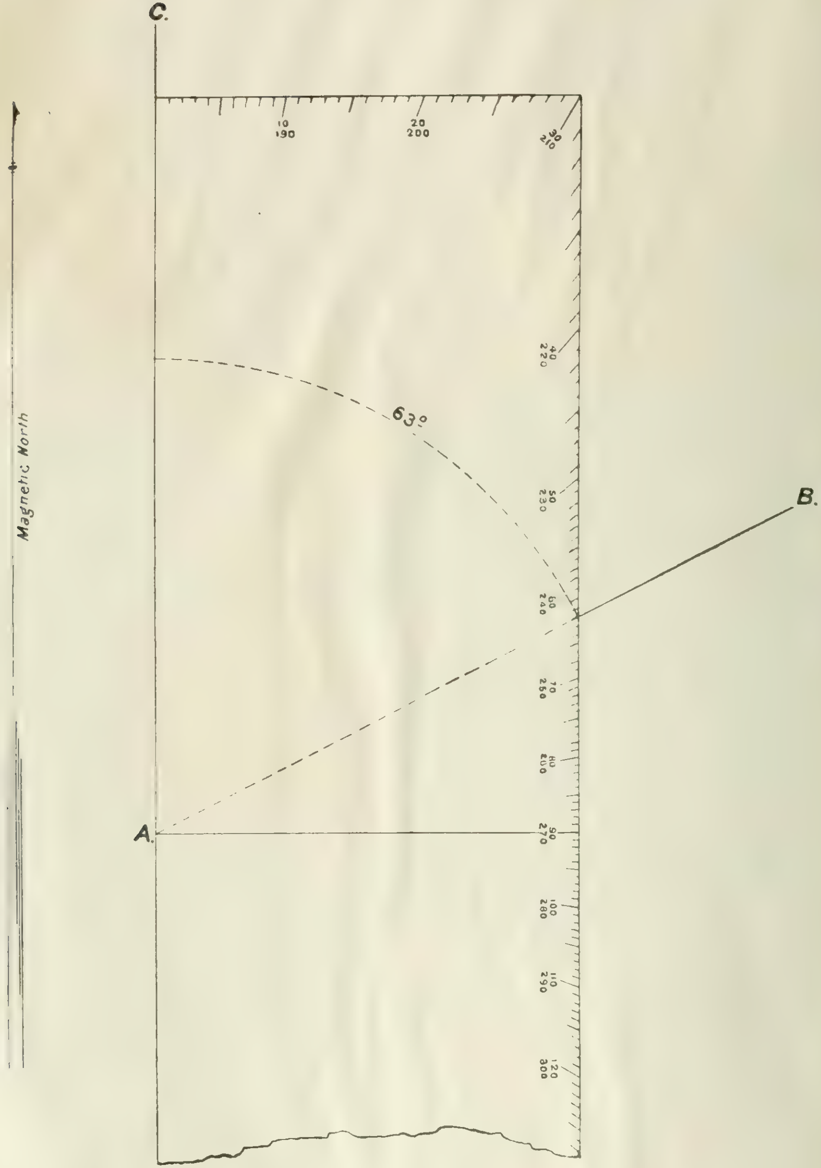

C.
10
190
20
200
30
210
40
220
63°
50
230
B.
60
240
70
250
90
270
A.
100
280
110
290
120
300
Magnetic North

Fig. 13

LESSON IX

Elevations—Contours--Construction of Model to Illustrate Contours

We have learned how to represent on the map the horizontal distance between points on the ground and also the direction of one point from another, but in order to have a better knowledge of the earth's surface we must devise some method of rapidly determining elevations. In other words we must know how high the hills are and how deep the valleys are and the extent of both.

This is done by means of CONTOURS, or lines cut from the surface of the earth by imaginary horizontal planes at equal intervals from each other.

The best aid in studying the principles of contouring is the sand-table. Previous to this lesson the artificer should construct a table about six feet square having a cleat about four inches high running around the edge, the table to be partially filled with clean moist sand.

In connection with exercises at the sand-table, the instructor should carefully construct a model to correspond to Map A. The model should be constructed in one corner of the sand-table, and should be of the same scale as Map A with a vertical interval of ½ inch equals 20 feet.

How to Construct the Model

In one corner of the table with cleats three inches wide, partition off a rectangle 22 inches by 28 inches.

By using tracing paper in connection with Map A, cut out Bristol board sheets corresponding to each of the imaginary planes.

Beginning at the datum plane (the table top) fill the ½ inch spaces between the sheets with ½ inch boards cut out with a scroll saw to conform to the horizontal planes cut from the earth. See Fig. 14.

The step-like intervals between contours should be filled in with putty and smoothed off to correspond to the earth's surface. See Figs. 14 and 15.

When the model has hardened, the intervals between contours may be painted green and the edges of the Bristol board which represent the contours, should be traced with white paint, especially if they have become soiled.

Contour numbers and elevations of hill tops should be indicated in white.

This model should be carefully constructed and kept for reference during the entire course. See Fig. 15.

The following principles of contouring are to be noted in connection with the model and Map A:

1. That all points on a contour line have the same elevation above the datum plane.

2. That where the contours are equally spaced the slope is uniform. (See a, b, c, d.)

3. That where contours are straight and evenly spaced, the ground is a sloping plane. (See e, f, g, h.)

4. That the contours of a vertical surface lie on top of one another, as in palisades. (As at H.)

5. That if the lean, in rocky formations, is over the base, then only can contours cross. (See x, y.)

6. That every contour closes upon itself or extends entirely across the map.

7. That on water-sheds the contours are convex toward the base of the slopes. (See i, j, k, l.)

8. That in water-courses the contours are convex toward the sources of the stream. (See m, n, o, p.)

9. That contours far apart indicate gentle slopes. (See q, r, s.)

10. That contours close together indicate steep slopes. (See t, u, v.)

Each member of the class should work at the sand table until he is able to represent each of the typical forms indicated above. He will then be required to combine two or more simpler forms, and finally he should be able to shape the sand into the most intricate combinations.

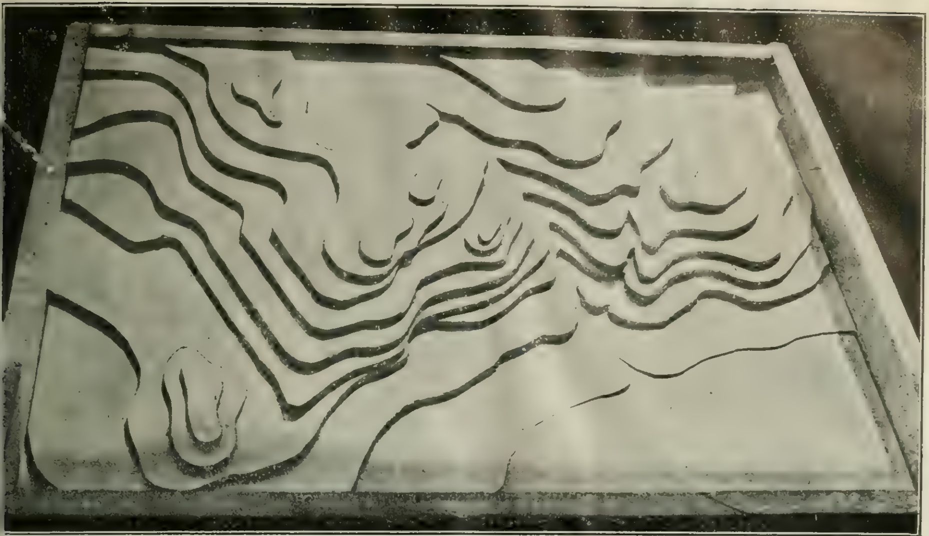


Fig. 14

Fig. 15

LESSON X

Orientation and Map Reading

Each member being provided with a map of the surrounding country, the class will now compare the map with the ground it represents.

In order to make these comparisons we must first see that the directions on the map and on the ground coincide. This is called "ORIENTING" the map.

All complete maps have both the true and magnetic meridian indicated. However, in a previous lesson you found the declination of the needle for your particular locality, so if either the true or magnetic meridian be given the other can readily be determined.

Methods of Orienting a Map

Ist method.—When the map has a magnetic meridian marked on it. Place the compass on the map, so that the needle pivot rests on the magnetic meridian, revolve the map, until the north end of the needle and the magnetic meridian point in the same direction, whereupon the map is oriented.

Suppose that only the true meridian is given on the map. Knowing the declination of the needle, construct a magnetic meridian and proceed as above.

If the magnetic declination is not more than five degrees, the map can be oriented nearly enough for map reading purposes by making the compass needle coincide with either meridian.

2nd method.—Suppose that neither the magnetic nor true meridian is on your map.

(a) Take a position on the ground corresponding to some point on the map. Identify another place on the map that you can see on the ground. Join the two maps' positions by a straight line. Hold the map so that this line points toward the distant point seen on the ground whereupon the map is oriented.

(b) Place yourself on the line of any two points visible on the ground and plotted on the map, rotate the map until the line joining the two points on the map points toward the two points on the ground, whereupon the map is oriented.

To locate one's position on a map.

1st.—When the map is oriented by compass.

Sight along the rule at an object on the ground at the same time keeping the rule on the plotted position of this object on the map. Draw a line toward your body. Find another point on the ground that is plotted on the map and repeat the process.

The intersection of the two lines is your map position. For reasons previously explained, to obtain the best results the two points selected should be so located that the lines drawn will form an angle not less than 30° nor greater than 150°. (See Fig. 10, Lesson V.)

2nd.—If the map has been oriented by means of a straight line drawn between two map points, then it will be necessary to draw but one line from an object on the ground, and the intersection of this line with the line already on the map will be your location on the map.

Having oriented the map and located your position on it, you should proceed along the roads and trails, keeping the map constantly oriented and comparing ground features with map features.

If you lose your position, verify it by one of the methods given above, or by estimating the map distance you should have traveled in a known time, or by actually pacing the course.

After each member of the class has learned to orient the map and to locate his position on the maps by all of the methods explained above, the instructor should accompany the class over some course comparing all ground and map features.

LESSONS XI AND XII

The Game of "Hide and Seek"

Two members of the class are selected to choose sides. One side is called the "Hiders," the other side, the "Seekers." All are provided with maps covering the area over which the game is to be played. This area should include at least four square miles, preferably of rolling country possessing few roads or trails and a considerable amount of vegetation.

The instructor then separates the "Hiders" from the "Seekers." Each "Hider" receives written instructions as to the location of his hiding place. The "Hider" will not be permitted to enter any enclosure, but will go, as nearly as he can estimate to the spot designated in his instructions, and by sitting or lying down conceal himself so that he cannot be seen at a distance greater than 100 yards.

The written instructions may read something like the following:

> Sergt. Jones:
>
> You will go to the point marked "A" on your map, and conceal yourself there as explained heretofore, and await further instructions from me.
>
> (Sgd.) J. M. SMITH,
> Capt., 24th Infty.

Each "Hider" will be equipped with map, compass, universal rule, pencil, eraser and pocket knife.

Before starting out each "Hider" must locate his present position on the map, he must determine the magnetic azimuth of A and the distance from his present position to A in terms of his paces. If there is some obstacle in the way so that he cannot take a direct course, he should select some other indirect course and determine the distances and azimuths of the various lines of the course selected. For example, suppose that he is at P and is directed to proceed to A, Fig. 16. He is unable to cross Green River except by the bridge at B, therefore he cannot take the direct course P A, but must go along the road P B, until he crosses the bridge and then proceed directly to A from B. In this case he would proceed to the bridge—then determine from his map the distance B A in terms of his paces and the magnetic azimuth of B A. If he has mastered the previous lessons he should be able to figure this all out for himself.

After a sufficient prescribed time has elapsed each "Seeker," (up to this time the "Seekers" have been unable to watch the proceedings of the "Hiders"), will be given instructions corresponding to some one of the "Hiders," and he will attempt to locate his "Hider" as soon as possible.

After due time has elapsed (the time being previously arranged) the instructor will have "Recall" sounded. At the sounding of "Recall" all "Hiders" and "Seekers" will remain in place standing.

The instructor will then verify positions. The "Seekers" score will be computed as follows:

For each "Hider" who was not hidden within 100 yards of his designated hiding place, the "Seekers" gain one point; they also gain one point for each correctly located "Hider" that is found by the corresponding "Seeker." The instructor's decision as to whether the "Hider" is properly located will be final.

The following day the "Seekers" will become the "Hiders" and vice versa. New hiding places will be designated and the proceedings of the previous day repeated. The side having gained the greatest number of points of course wins.

This game may be played between Sergeants and Corporals, or in any other way to insure the greatest competition. Certain privileges may also be granted to the winning team.

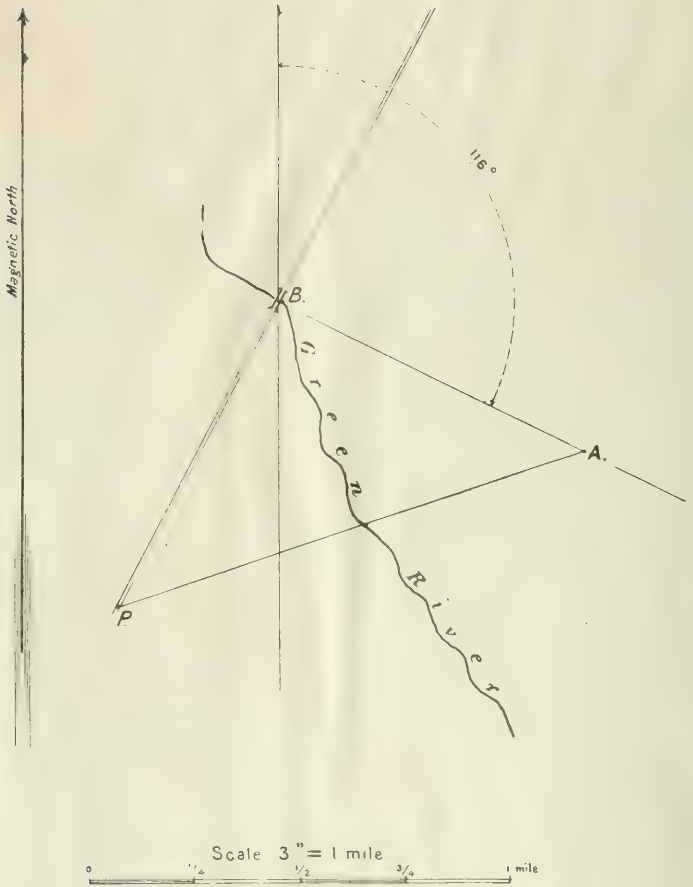

Magnetic North
116°
B.
A.
P.
Green
River
Scale 3" = 1 mile
0
1/4
1/2
3/4
1 mile

Fig. 16

LESSON XIII

Measurement of Angles of Slopes—Construction of Slope Board —Scale of Map Distances

From the model constructed in a previous lesson in connection with Map A, and work at the sand-table, the student should now understand what contour lines are, and the necessity of placing contour lines on maps in order to form a correct idea of the locations and extent of the elevations and depressions of the earth's surface.

The surface of the ground is either level or sloping. As one walks along a level course his elevation naturally remains the same, while, if he walks along a sloping course, his elevation increases or decreases according as he is going up or down hill.

It has been found that the up hill end of a line 57.3 feet long which has a slope of one degree is one foot higher than the down hill end. Computing from these figures we are able to determine the difference of elevation between any two points if we know the distance and the angle of slope between the points. The distance may be determined by pacing, intersection, resection, etc., and the angle of slope by various instruments especially prepared for that purpose most of which are rather expensive and quite apt to get out of adjustment.

The most practicable method of ascertaining angles of slopes is by means of the slope-board which is inexpensive, easy of construction and never gets out of adjustment.

Method of Construction

On your drawing-board (see Fig. 17) construct D C perpendicular to A B, then when a point is sighted along the straight edge A B, the plumb line attached at D makes the same angle with the perpendicular D C that A B makes with the horizontal.

Lay off D E, 5.73 inches long on D C, then with the radius D E describe the semi-circle F E G. Lay off from E toward F and G successive distances of 1-10th inch along the arc. These divisions represent degrees, because one degree in a circle of 5.73 inches radius gives a cord of 1-10th inch. Extend these degree marks to the foot of the board with a ruler as shown in Fig. 17.

To read slopes, attach a plumb line at D, sight along A B at the object, keeping the board in a vertical plane. When the plumb line comes to rest, press the string against the edge of the board with the fingers and read the angle marked.

Having a drawing-board equipped with the device for reading angles of slope, a scale of M.D.'s (map distances between contours), will now be explained. Such a scale will be found on the Universal Rule for Military Sketching and Map Reading.

Scales of Map Distances may also be obtained from the Secretary, Army Service Schools, Fort Leavenworth, Kansas.

A Normal System of Scales has been prescribed for U. S. Army field sketches as follows:

Sketches of large areas	1 inch = 1 mile,	V.I., 60 feet.
Road sketches	3 inches = 1 mile,	V.I., 20 feet.
Position sketches	6 inches = 1 mile,	V.I., 10 feet.
Fortification sketches	12 inches = 1 mile,	V.I., 5 feet.

It will be seen that as the scale is increased the vertical interval between contours is proportionally decreased, so that by this system the M.D. is always the same for the same angle of slope whatever the scale of the map may be.

The M.D. for any angle of slope may be computed from the following equation: $\frac{688 \times \text{R.F.} \times \text{V.I.}}{\text{Angle of slope}} = \text{M.D.}$ in which 688 equal the horizontal distance in inches on a one degree slope necessary to give a rise of one foot. The V.I. is expressed in terms of feet.

If the R.F. and V.I. for any sketch made in accordance with the Normal System be substituted in the above equation the M.D. will be the same for any particular angle. In view of this let us substitute R.F. = 1-63360 and V.I. = 60, and let the angle of slope be one degree, and we have $\frac{688 \times \frac{1}{63360} \times .60}{1} = .65$ inch (the M.D. for one degree slope for any sketch under the Normal System.)

Dividing .65 by ¼, ½, ¾, 1, 2, 3, 4, etc., we have the M. D. for ¼, ½ degrees etc., as shown on the Universal Rule.

Maps with R.F. and V.I. corresponding to the Normal System should be issued to the class, and each man should determine angles of slope between contours on the maps. In this connection the following table of practicability of slopes should be studied:

Degrees of slope	Operations.
1	Maximum for railroads.
3	Maximum for first-class roads.
5	Practicable for all arms. Somewhat difficult for cavalry to charge descending.
6	Maximum for cavalry charge in mass ascending. Infantry in close order descends with some difficulty.
7	Cavalry can descend at a trot.
8	Not practicable for heavy loaded vehicles.
9½	Field artillery can no longer maneuver.
14 to 15	Maximum up to which all arms can move.
18½	Light vehicles can ascend.
26	Foot troops can ascend or descend aided by hands.

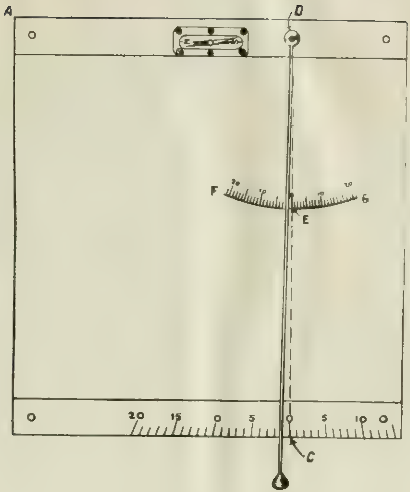


Fig. 17

LESSON XIV

Profile Method of Spacing Contours

Having constructed our slope board and scale of map distances for slopes we will now determine the methods in detail of finding the elevation of an unknown point D, from a known point A, and the location of contours on this line.

A D is the road to be contoured. Draw several lines parallel to A.D. with a vertical interval of 1-20 inch.

A b c d is a profile of the road, vertical scale 1-20 inch equals 20 feet.

A profile is a line supposed to be cut from the surface of the earth by an imaginary vertical plane.

It is customary to draw a profile with a greater vertical than horizontal scale in order that the slopes of the hills may appear more clearly to the eye.

Glancing at the profile of the road A D, we find conspicuous points of elevation or depression as b c and d, these are called CRITICAL POINTS, or points where there are abrupt changes of general slope. It is seldom the case that a slope is uniform. There are constant slight changes of slope (see Fig. 18, A to b) and occasionally a decided change as at b c and d. If we should attempt to ascertain every change of slope, it would be an endless and confusing task, and our error would constantly be multiplying. Instead, we start at A which is known to be 900 feet above sea level. We glance along the road ahead of us and see numerous slight changes of slope, and finally at b is a hill top that stands out conspicuously. With the slope board we sight at b and find the angle of slope to be 3½ degrees.

We now pace from A to b and lay off the distance A B. (All road sketches, as stated before, are drawn to a scale of 3 inches equals 1 mile and a V.I. of 20 feet.)

Applying our scale of Map Distances for 3½ degrees to A B, we find that it is contained 4½ times.

Multiply 20 feet (the contour interval) by 4½ and we find that the elevation of b is 990 feet.

At B erect the perpendicular Bb 4½ of the 1-20 inch spaces in height, each space representing 20 feet. Mark b, 990 feet.

Now from the hill, b, glance backward at A and plot the profile Ab as the road actually appears to you. Where this profile intersects the horizontal lines drop perpendiculars to the line A E which represents your road. By this method you have the elevations of the critical points determined very accurately and the intervening contours spaced correctly enough to give a very good idea of the slopes.

Having located the contours on the road between A and B, extend each contour to the right and left of the road as far as you can see plainly, so as to represent the true conformation of the ground (see Fig. 18.)

From b sight at the next critical point, c. You find that the angle of elevation is two degrees. Pace b c and lay off the distance B C. Apply your scale of map distances. It is contained $3\frac{3}{4}$ times. $4\frac{1}{2}+3\frac{3}{4}=8\frac{1}{4}$.

At C erect a perpendicular $8\frac{1}{4}$ spaces high and mark elevation of c, 900+ $(8\frac{1}{4}\times 20)$ or 1065 feet.

From c, plot the profile of the road, c b as it actually appears to you, and where the profile intersects the horizontal lines drop perpendiculars to the line B C, thus locating your contours between B and C.

Proceeding in the same manner from c to d, you find an angle of 4 degrees "depression." Pace c d, and lay off the distance C D. Applying your scale of map distances to C D you find that it is contained $5\frac{1}{2}$ times. $8\frac{1}{4}—5\frac{1}{2}=2\frac{3}{4}$ or d is $2\frac{3}{4}$ spaces above the datum plane, or has an elevation of $900+(2\frac{3}{4}\times 20)=955$ feet.

After a most careful explanation of the above method of contouring, the instructor should issue profile paper to each member of the class. He should then indicate distances and slopes between imaginary critical points, and the members of the class will lay off the distances, using any one of the Normal Scales, apply their M.D. (map distance) scale and erect perpendiculars at the critical points, indicating their elevations. They will then draw in any imaginary profile of the road between critical points and drop perpendiculars from the intersection of the profile with the horizontal planes.

For slopes of less than five degrees, the vertical scale of the profile should be reduced to 1-10 inch.

The next two lessons will involve the actual field work, employing the principles taught in this lesson.

We must learn to creep before we walk, and it is believed that after two days practice in contouring with the aid of the profile method that the student will be able to space the contours between critical points without using the profile paper.

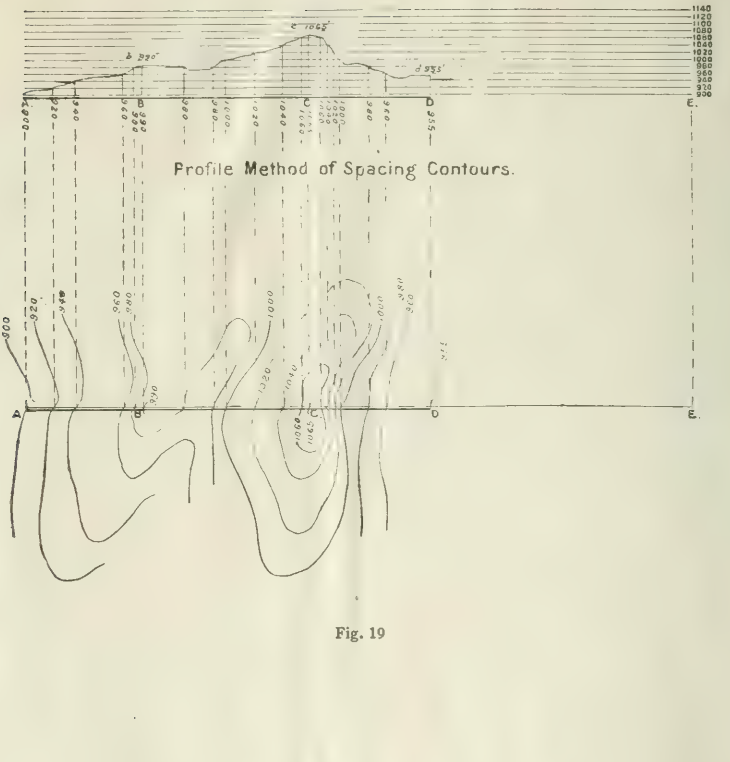

Profile Method of Spacing Contours.
A
B
C
D
E.
1140
1120
1100
1080
1060
1040
1020
1000
980
960
940
920
900

Fig. 19

LESSONS XV, XVI AND XVII

Contouring (Continued)

The instructor should select a road or course two or three miles long possessing a few well defined critical points.

Each sketcher should be equipped with a drawing-board with compass and the attachment for reading slopes, the Universal Rule, a hard well-sharpened pencil, knife and eraser, also profile paper, with either 1-10 inch intervals or 1-20 inch intervals. If the course is rugged use the 1-20 inch profile, otherwise the 1-10 inch profile.

The instructor should emphasize the importance of using hard pencils and keeping them well-sharpened for this work. He should also accompany the sketchers, constructing the profile and contours of the road.

When the work has been completed the class should be assembled, results compared and errors pointed out.

Lessons XV and XVI are devoted to this method of contouring after which it is believed that the sketcher's eye will be trained so as to enable him space the contours between critical points with a fair degree of accuracy.

For Lesson XVII the instructor should indicate a course about three miles long as in the above lessons, but the contours between critical points are to be drawn in without the aid of the profile paper.

After each lesson the class should be assembled and results compared.

LESSONS XVIII AND XIX

The Road Sketch Complete

We have learned how to plot on the map ground distances, directions, elevations, and the various natural and artificial ground features of military importance.

We will now make a complete road sketch. The instructor will designate some road, say, three or four miles long. Each member of the class will go over the designated road, plotting distances, directions, elevations and important ground features as outlined in previous lessons.

The sketch should not only include the road itself but an area extending 400 yards each side of the road. As a rule most of this area can be seen from high elevations along the road-bed, but occasionally it may become necessary to go to an elevated point outside of the road to secure all of the details. Important objects such as high hills, towns, etc., which are more than 400 yards from road-bed should be located by intersection. When hills have been located by intersection their elevations should be determined by applying the Scale of Map Distances and the elevations noted on the sketch.

The most practicable method of indicating details on maps or sketches made in the field is shown in Fig. 19. Vegetation, fences, etc., should be indicated by words rather than by the proper conventional signs. In short the best field method is the quickest and most accurate method. For more elaborate map work the authorized conventional signs may be used as shown in Fig. 20.

In order that the student may become familiar with all of the conventional signs which is very important when it comes to map reading, the field sketches may be retouched at leisure employing the proper conventional signs in each case, as shown in Figs. 19 and 20.

The beginner should sketch in every feature of military importance, so as to become familiar with the Conventional Signs and to train the eye to observe details. Later, he may be called upon to submit sketches showing only such information as might be required for particular expeditions.

At the close of the lesson the instructor will collect the sketches, and before the next lesson he will note on each sketch all the glaring defects.

At the beginning of Lesson XIX the sketches will be returned, errors and omissions pointed out, and a new road of about the same length as the one in the previous lesson will be designated, so that Lesson XIX will be the same as Lesson XVIII, except that the sketcher will be in a position to profit by the experience of the last lesson.

A Few Rules to be Observed

1. The beginner should never attempt to hurry, even if he is unable to complete the task assigned to him.

2. Devote equal time and care to all parts of the sketch.

3. Be sure that your orientations are correct and that your board is kept oriented.

4. Do not leave a station or critical point until all of the details up to that point have been put in.

5. Do not attempt to show too minute details. You must get the distances, directions, elevations of critical points, and by intersection locate only such landmarks as may assist you in identifying your location later, or that are of military importance, such as high hills, towns, etc. By close observation and taking a few notes as you pass along the road, the remaining details such as fences, cultivated fields, buildings, cuts and fills, bridges, railroad crossings, telegraph lines, etc., may be filled in from the critical points.

6. Be sure that the drainage has been properly outlined before attempting to extend the contour lines each side of the road, in other words, first locate conspicuous hill tops and the course of stream beds and valleys. This is most important, as extending contour lines without first indicating what we may call the frame-work of the drainage would be like fitting a garment without trying it on or without making previous measurements.

7. To become a rapid and an accurate sketcher one must be able to estimate distances with less than ten per cent error up to 600 yards and within fifteen per cent up to a mile. Estimates of distances should be made in yards and the ground distance and map distance for 100 yards should be distinctly fixed in the mind as reference units. (See Estimating Distance Firing Regulations, U. S. Army.)

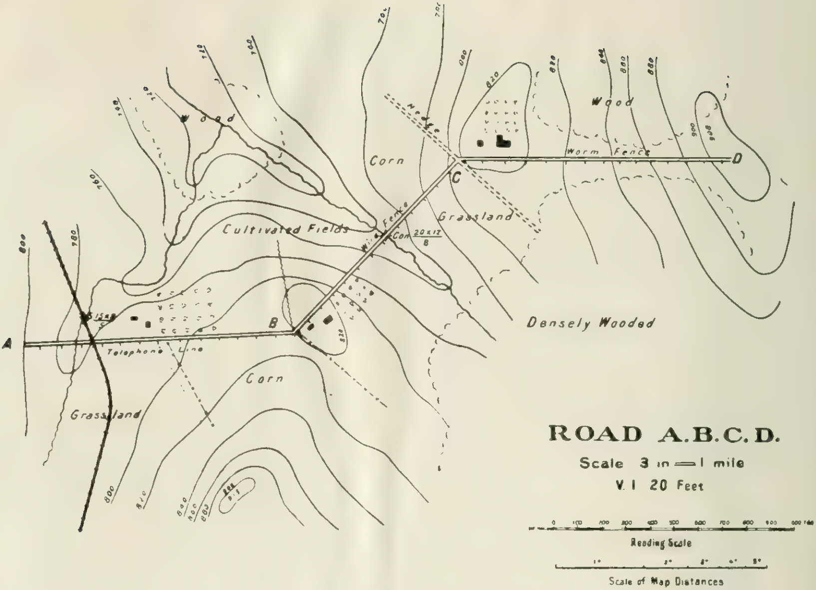

Wood
Corn
Hedge
Worm Fence
Wood
C
D
Grassland
Cultivated Fields
Wire Fence
Densely Wooded
A
B
Telephone Line
Corn
Grassland
ROAD A.B.C.D.
Scale 3 in = 1 mile
V. I 20 Feet
Reading Scale
Scale of Map Distances

Fig. 19

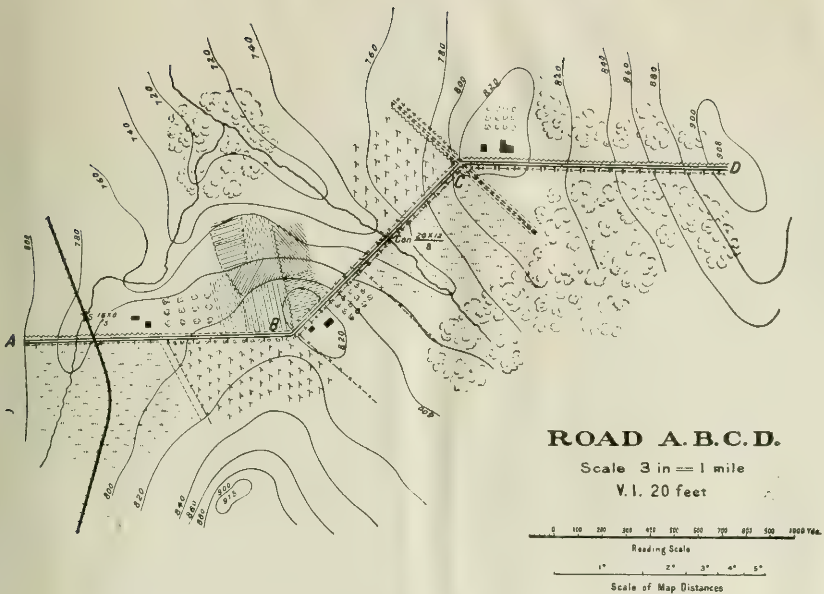

A
B
C
D
ROAD A. B. C. D.
Scale 3 in = 1 mile
V. I. 20 feet
Reading Scale
Scale of Map Distances

Fig. 20

LESSON XX

Position Sketch

Military sketches may be classified as "Road Sketches" and "Area Sketches." We have already discussed the Road Sketch in Lessons XVIII and XIX. Area Sketches are classified as:

1st. The Position Sketch, in which military conditions are such that the sketcher is at liberty to visit any part of the area to be sketched.

2nd. The Outpost Sketch in which the sketcher is usually able to visit only that part of the area in rear of his own line of observations.

3rd. The Place Sketch, which is made by the sketcher from one point of observation.

In this lesson we will consider only the Position Sketch. The scale of this sketch is six inches equals one mile with a contour interval (V.I.) of ten feet.

For the beginner, the work involved in making a position sketch is divided into two parts:

1st. The Frame-work.
2nd. Filling in details.

The Frame-Work

To illustrate, you are required to make a Position Sketch covering an area of one square mile. The construction of the frame-work (that is the location of a sufficient number of critical points as will enable the sketcher to fill in all details of military importance), is divided into three distinct parts:

1st. Select and measure a Base Line.
2nd. Location of Critical Points by Intersection.
3rd. Location of Points by Resection.

The Base Line

The base line should be about one-third as long as the greatest dimension of the area to be sketched. (See A B, Fig. 21) and should be as centrally located as possible. Its ends should be marked by some conspicuous natural objects. If this is not practicable, poles with white banners should be placed at the ends, or any other method by means of which these points may be seen from a distance. The base line should be on as level ground as practicable with a good view over the ground to be mapped. If the country is hilly a good base can usually be established along some ridge.

Intersection and Resection

Suppose that we have selected the base line A B, Fig. 21. From the extremities and known points on this base line the points (indicated by letters C D E F G H I, Fig. 21) may be located by intersection as explained in Lesson V. Any other required points throughout the area (indicated by figures 1, 2, 3, 4, 5, 6, 7 and 8, Fig. 21) may be located by resection as explained in the same lesson.

Points located on the sketch by intersection and resection should be such as will outline the drainage system, as, for example, conspicuous hill tops, bridges and important bends in the course of streams, the junction of streams and deep valleys, etc., also any other points that will assist in making a frame-work for the sketch or in locating the sketcher's position.

Filling in Details

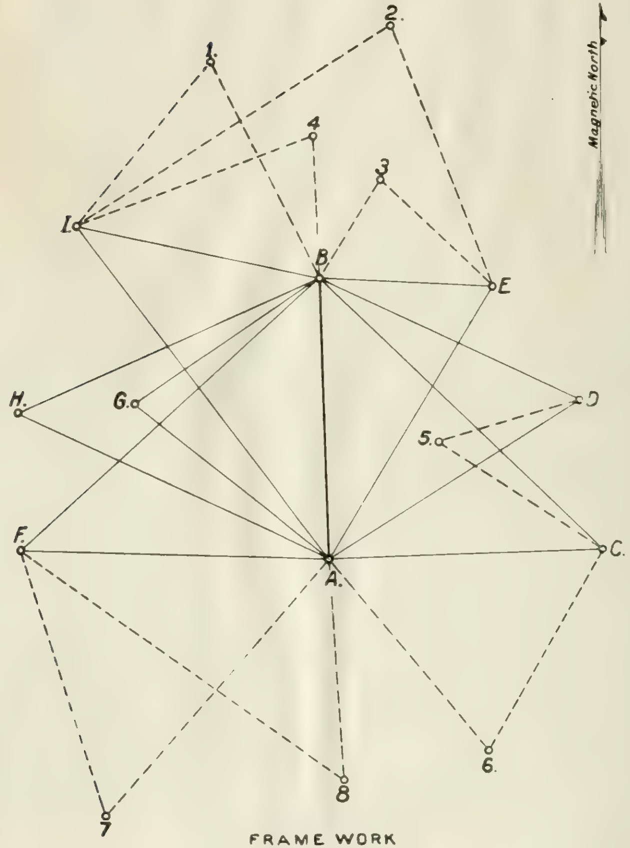
Angles of elevation or depression between points located by intersection or resection will be measured, the M.D. scale applied to the lines connecting these points and their elevations noted on the sketch. Then with the drainage system outlined, and the elevations of many points known, the sketcher should experience no difficulty in drawing in the contours by eye.

Other details such as the vegetation, buildings, bridges, cuts, fills, fords, ferries, roads and trails, etc., may be sketched in from points located by intersection and resection.

Bear in mind the importance of outlining the drainage before drawing in any contours.

Fig. 22 includes the same area as Fig. 21, with the details sketched in.

After the instructor has thoroughly explained the subject of BASE LINES, INTERSECTION AND RESECTION, he will take the class to some large room in barracks, and locate all of the main features of the room by establishing a base line on a conveniently large scale, say 1-40, and locating points by intersection and resection. He should assure himself that each member of the class understands the principles involved in making a Position Sketch, as in the following lesson they will be required to actually perform the work in the field.



FRAME WORK
POSITION SKETCH.
Scale 6" = 1 mile

A. B. is the Base Line
C. D. E. F. G. H. I. Points located by intersection
1. 2. 3. 4. 5. 6. 7. 8 Points located by resection
Intersection lines are plain.
Resection lines are broken.

Fig. 21

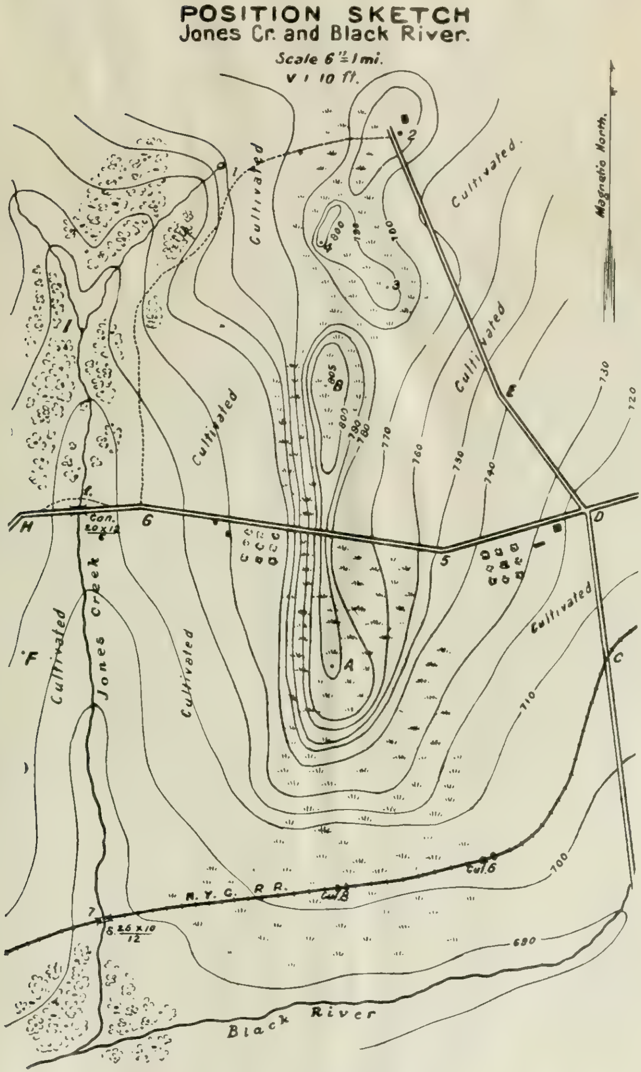

POSITION SKETCH
Jones Cr. and Black River.
Scale 6" = 1 mi.
V I 10 ft.
Magnetic North.
Cultivated
Jones Creek
Black River
N. Y. C. R. R.
Con. 20 x 12
S. 26 x 10 / 12
Cul. 6
Cul. 8
A
B
C
D
E
F
H
1
2
3
4
5
6
7
800
790
780
770
760
750
740
730
720
710
700
690

Fig. 22

LESSONS XXI, XXII AND XXIII

Position Sketch (Continued)

The instructor should designate a certain area of about one square mile to be sketched, and will go over the ground selected with the class and choose a suitable base line as described in the previous lesson.

After the base line has been decided upon each member of the class will proceed to construct the frame-work of the sketch by measuring and laying off the base line and locating points by intersection and resection. Perhaps no two men will select the same critical points throughout the entire framework. This does not matter.

In constructing the frame-work of a position sketch, the following points should be remembered:

1. Exercise great care in pacing and laying off the base line.

2. See that the directions of the base line and magnetic meridian as plotted on your sketch correspond exactly with the direction of the base line and the compass needle.

3. In locating points by intersection and resection, see that your drawing-board is exactly oriented. Pivot your ruler carefully, and sight accurately at the ground objects. Use a hard well-sharpened pencil.

The class will be instructed to locate a certain number of points by intersection and a certain number by resection. When this has been accomplished, results will be compared and errors pointed out. The work should be criticized by the instructor before leaving the area sketched.

Lesson XXII will be devoted to filling in details as shown in Fig. 22, Lesson XX.

For Lesson XXIII a certain area will be designated by the instructor but the men will select their own base lines, and details will be filled in as the frame-work progresses.

LESSONS XXIV AND XXV

The Outpost Sketch

The same methods, scale, and V.I. are employed in making an outpost sketch as are used with the position sketch with the one exception, that, in the former case the sketcher is unable to visit that portion of the area to be mapped beyond the line of observation.

The location of the base line will depend upon the nature of the ground and whether or not the sketcher is under fire. In some cases it may be located along the line of observation, and points to the front located by intersection or estimation. When under fire it would be necessary to locate the base some distance in rear of the line of observation, locating points between the base and the line of observation by either intersection or resection, and points beyond the line of observation by intersection or estimation. Several critical points should always be located along the line of observation, the sketcher approaching these points by creeping up from the rear, orienting his board flat on the ground, and sighting necessary critical points over the foreground.

The non-commissioned officer in time of war will frequently be called upon to make a sketch of that portion of the outpost including one support, its outguard, line of observation, etc., and if he hopes to be really efficient and render his country the greatest service possible in time of need, he should exercise the greatest pains in mastering this lesson in connection with paragraphs 123 to 141 inclusive, Field Service Regulations, 1913, which will give him a very good idea of the features to be noted on the sketch.

Field glasses will be found very useful in studying the foreground, thus showing up many folds of the ground not visible to the naked eye. The ground must be shown from one-half to two miles in front of the line of observation, this of course depending upon the nature of the country.

The instructor, after explaining the preceding portion of this lesson, should march his company or troop to suitable grounds, establish an outpost, and require each non-commissioned officer to submit a sketch, showing all the ground features, locations of support, outguards, and sentinels, lines of retreat, and in fact every detail of military importance that the commander of the outpost should know. Sketches to be submitted and errors pointed out before the outpost is relieved.

The operation will be repeated in Lesson XXV, a new location for the outpost being selected.

LESSONS XXVI AND XXVII

The Place Sketch

It is often necessary to sketch a certain area from one point of observation. This is called a Place Sketch. It is also made on the same scale and with the same V.I. as the position sketch.

In time of war there is a great demand for sketches of this class from non-commissioned officers. Fig. 23 will illustrate the method of construction which is very simple. However, in order to produce a Place Sketch of value, the sketcher must possess the ability to estimate distances with less than ten per cent error up to (600 yards and with fifteen per cent up to a mile. The sketcher should again familiarize himself with the rules for estimating distances as given in the "Small Arms Firing Regulations;" Telephone and Telegraph poles are usually set up at fixed distances which often will be of great assistance. In many parts of the country the land is divided into sections, and the sections sub-divided in such a manner as will aid the sketcher in making correct estimations.

As estimations of distances are made in yards, a working scale of yards, 6 inches equals 1 mile, is necessary. Such a scale will be found on the Universal Rule for Military Sketching and Map Reading.

Construction of Place Sketch

Your instructor directs that you go to a point A, and make a Place Sketch including the area within a radius of one-half mile of A and east of a N. and S. line through A.

The sketcher proceeds to A, orients the board with the needle. He looks over the area to be sketched and picks out the critical points C and D, first getting their direction and then laying off the distance by estimation. By counting the telephone poles he will be able to determine the distance C D which may be used as an aid in estimating other distances. He extends the road E. from D and W, from C. With this base carefully plotted, he is able to sketch in the river, creek, rail-road station, rail-road, houses and bridges. If he has field glasses he will be able to ascertain the construction and make a very close approximation of the dimensions of the bridges.

Now he wishes to represent the hills and valleys.

Naturally the lowest part of his sketch is down stream part of Green River. This is his datum plane. For convenience he calls this zero. He carefully estimates the distance to O, reads his slopes and with his scale of M. D. determines his elevation at A. He then spaces in the contours between A and O. In a similar manner these contours are prolonged so as to include the entire sketch. Vegetation and other important details are noted.

In no other way could this soldier convey as much information to his commanding officer. By sending several good sketchers out to various points the commanding officer will soon have before him a very good map of the surrounding country.

After the above has been carefully explained, the instructor will post each member of the class in the same locations as he might the outguards of an outpost, and require each man to make a place sketch including a certain well-defined area to the front of his position. When the sketches are completed, they will be turned in and the class dismissed.

The following lesson (XXVII), the instructor, accompanied by the entire class, will proceed in turn to each of the positions occupied by the sketchers on the previous day. Members of the class other than the sketcher who occupied the position will be required to orient the sketch, both by compass and by known points, to check the directions, distances, and in fact review the entire sketch. By this method many points will be brought out, and, at the same time, every man will be keen to do his best, knowing that his work is to be reviewed by the entire class.

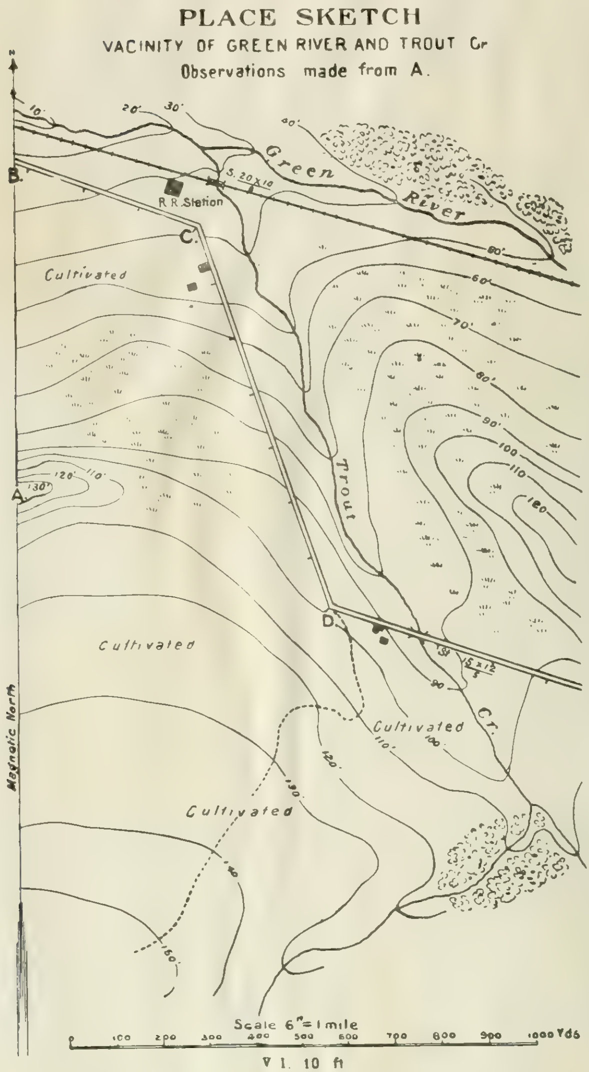

PLACE SKETCH
VACINITY OF GREEN RIVER AND TROUT Cr
Observations made from A.
Green River
R R Station
S. 20 X 10
Cultivated
Trout Cr.
Cultivated
Cultivated
Cultivated
15 x 12
Magnetic North
Scale 6" = 1 mile
0 100 200 300 400 500 600 700 800 900 1000 Yds
V I. 10 ft

Fig. 23

LESSON XXVIII

Visibility

It is often necessary to determine from the map whether one point is visible from another; whether a certain line of march is concealed from the enemy; how much of a certain area can be seen from a given point; and whether slopes are uniform, concave or convex. If the map is correct the above information can be determined very accurately in the following manner:

See Map A.

1st. By studying Map A in connection with the Model, Fig. 15, the following principles of visibility are obvious:

(a) Contours closely spaced on the top of a hill, and gradually getting farther apart toward the bottom, as H I J K, show a concave slope, and all points of the intervening surface are visible from both the top and bottom of the slope.

(b) Contours spaced far apart at the top and gradually closer toward the bottom, as L M N O P, show a convex slope, and neither end of the slope is visible from the other.

(c) Parallel contours equally spaced as e f g h, indicate a plane surface, and all intervening points are visible from top to bottom of the slope.

Bearing the above principles in mind, one is often able to tell at a glance whether or not one point can be seen from another. If visibility cannot be determined by eye, the simple method explained later in the lesson, can always be relied on.

Visibility problems may be divided into three classes:

1st. To determine whether or not one point is visible from another.

2nd. To determine how much of the ground line connecting the two points is visible from either point.

3rd. To determine how much of a certain area is visible from a given point.

With an understanding of the three principles of determining visibility by inspection, and the ability to solve the three problems noted above, the student will be prepared to solve any visibility problems that may arise. Each member of the class should become familiar with the method of solving point, line, and area problems in visibility as explained. (See Map "B," Figs. 3, 4, 5, and 6.)

LESSON XXIX

Visibility (Continued)

The instructor should issue the best available contoured map of the surrounding country to each member of the class. (The Geological Survey Maps are excellent for this purpose.) Each man should be required to solve problems involving the visibility of points, lines, and areas from some selected point of observation on the map. The results should be verified by the instructor and retained for comparison with the ground features in the following lesson.

LESSON XXX

The instructor should now march the class to the point of observation selected in the previous lesson and each man, after orienting his map, will compare the actual visibility of points, lines, and areas with his results of the previous lesson. In this manner the accuracy of the map as to contours can readily be determined.

APPENDIX

Construction of Scale of Paces

Sergt. Jones paces a course of a thousand yards four times with the following results:

1st result, 1118 paces.
2nd result, 1109 paces.
3rd result, 1120 paces.
4th result, 1117 paces.

He wishes to construct a working scale of paces, 3 inches on the scale representing one mile on the ground.

To do so he should proceed as follows:

1st. Find the length of his pace.
2nd. Find out how many of his paces will be represented by one inch on the map.
3rd. Find the length in inches of his working scale.
4th. Construct the scale.

1st. To find the length of his pace:

1118
1109
1120
1117
———
4464 ÷ 4 = 1116 paces (average number of his paces for 1,000 yards).
1,000 yds. = 36,000 inches.
36,000 ÷ 1116 = 32.2 inches the length of his pace. (If the decimal is .5 or less use the number below, if greater than .5 use number above.)

Sergt. Jones' pace is 32 inches long.

2nd. To find out how many of his paces will be represented by one inch on the map.

3 inches on map = 63,360 inches on ground.
1 inch on map = 21,120 inches on ground or (21,120 ÷ 32) = 660 of his paces.

3rd. To find the length in inches of a convenient working scale representing say 2,400 paces:

660 paces = 1 inch.
2400 ÷ 660 = 3.63 inches = length of scale.

4th. To construct the scale:

Lay off the line A B, 3.63 inches long, which represents 2,400 paces.

Divide this line into 24 equal divisions representing 100 paces each.

Divide the first one of these smaller parts into five equal divisions of 20 paces each. (See Fig. a.) Transfer these sub-divisions to the Universal Rule and the scale is completed.

To divide the line A B, Fig. a, into 24 equal divisions, lay off any line A C that can be conveniently divided into 24 equal parts. Connect B C, then draw lines parallel to B C as shown in Fig. a. These will divide A B into 24 equal parts each representing 100 paces. Use the same method for divisions representing 20 paces.

Method of Constructing Drawing-Board with Tripod and Prime Attachment for Reading Slopes

The Drawing-Board

The drawing-board should be of soft pine $13'' \times 14''$ and 1 inch thick. This will allow a drawing surface sufficient to include four square miles of position sketch and enough extra space to secure the paper to the board.

The Tripod

Take a piece of "Two by four" five inches long. (See Fig. b) and three sticks $4' \times 1'' \times \frac{1}{2}''$, the latter of some tough material which will not be easily broken. About $\frac{3}{4}$ inch from the end of these sticks bore holes $\frac{1}{2}$ inch in diameter.

At the middle of one end of the block saw out a slit $\frac{3}{4}$ inch wide and extending $1\frac{1}{2}$ inches into the block. By means of wire nails driven as shown in Fig. c attach the three legs to the block, one leg in the slit and the remaining two legs at the other end of the block. Then drive a wire nail into the centre of the bottom of the block; the nail being of sufficient length so that it will protrude $\frac{3}{4}$ of an inch out of the block, (see Fig. c). When all of this has been completed you will have a tripod something like Fig. d. Now bore a hole $\frac{3}{4}$ of an inch deep into the center of the bottom of your drawing-board, the diameter of this hole being just sufficient to accommodate the wire nail protruding from the top of the tripod. Now attach the drawing-board to the tripod by means of the nail and hole just described and you will have a drawing-board and tripod complete, by means of which the board can be quickly oriented and leveled, also the board is easily detached from the tripod when it becomes necessary to read angles of slope.

Attachments for Reading Angles of Slope

See Lesson XIII, Fig. 17. This attachment should be constructed at the same time that the drawing-board and tripod are made in order to be ready for use when required.

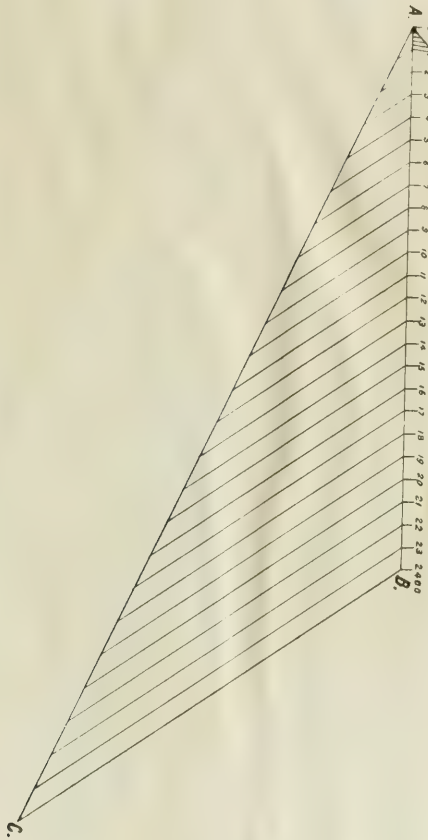


Fig. A

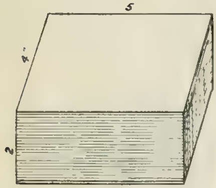


Fig. b

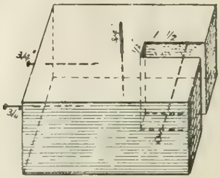


Fig. c.

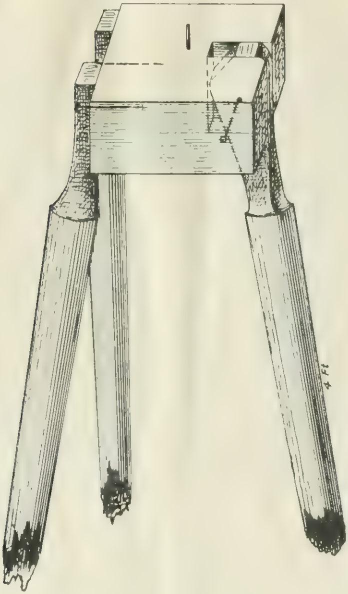
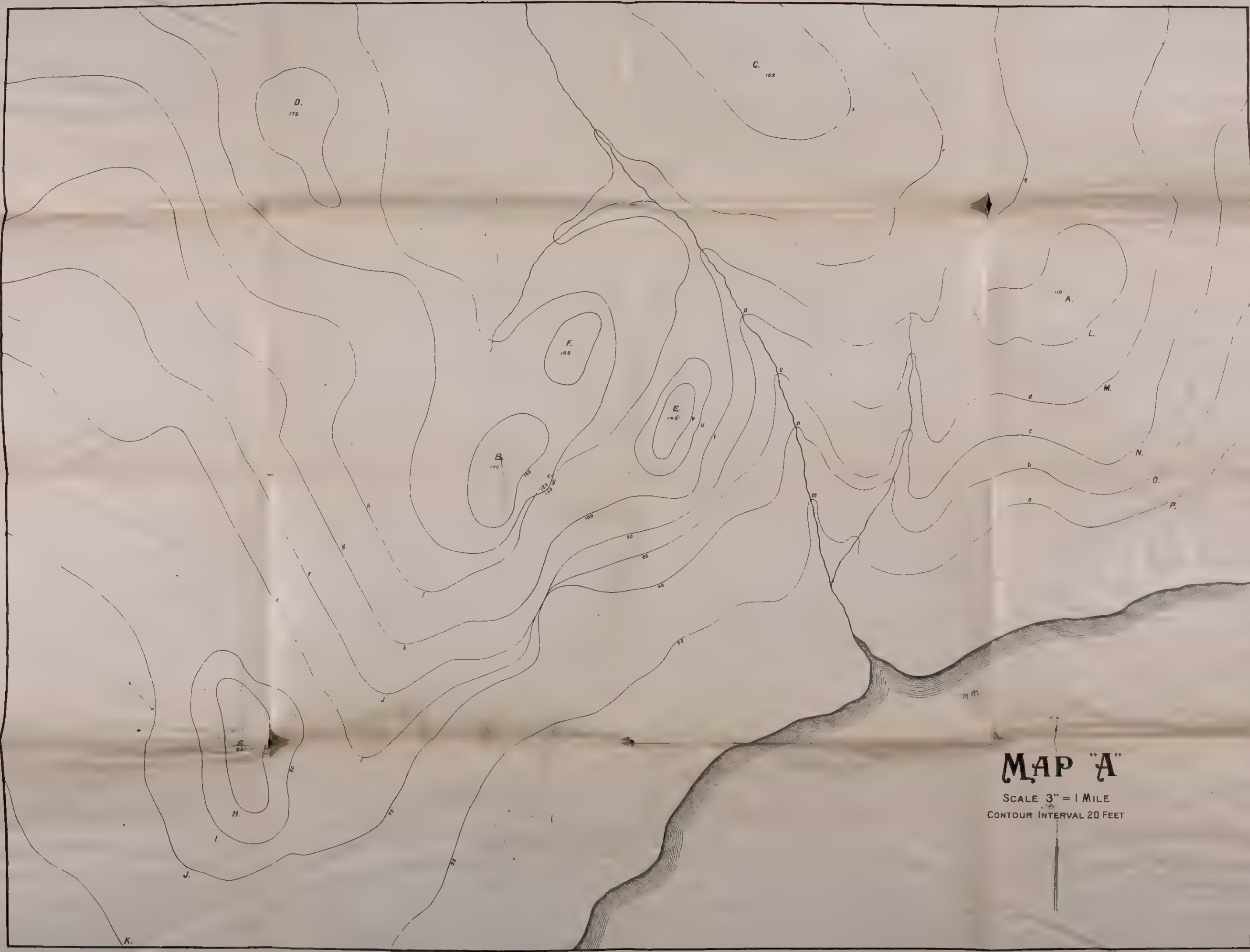


Fig. d


MAP "A"
SCALE 3" = 1 MILE
CONTOUR INTERVAL 20 FEET
C.
162
D.
175
A.
L.
M.
N.
O.
P.
F.
166
E.
B.
170
H.
I.
J.
K.

MAP "B"

UNIVERSAL RULE
for
Military Skeching and Map Reading
by

1st. Lieut. Loren C. Grieves 24th Inf.
Incharge of Map Section
Military Information Division

Manila P.I. December 1913.

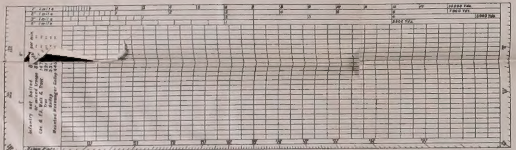


Fig. I.

Figs. I and II represent the actual dimensions of the rule. It is made of white celluloid so that all notations may be readily erased and being a true rectangle, it may be used to construct parallel and perpendicular lines.

On this rule may be found the following:

A protractor.

Scale of Map distances.

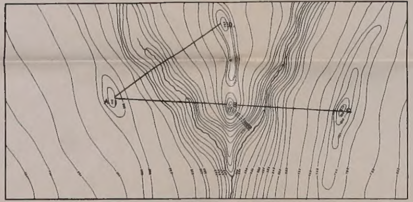
Space to inscribe various scales of paces.

Reading scale in yds for one, two, three, and six inches to the mile.

Rate of speed in yds per minute for the various arms of the service.

A simple means for solving all visibility problems within the range of field artillery.

It may also be used as a memorandum pad and message blank.



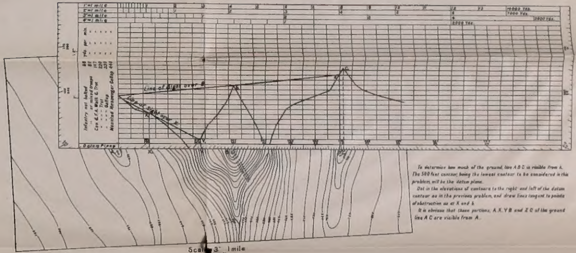
Scale 3" 1 mile
V.I. 20'
Fig. III.

From the map, Fig. III determine:

1st. Whether the point C is visible from A.

2nd. How much of the ground line A B C is visible from A.

3rd. How much of the area included within D A B C is visible from A.



Scale 3" 1 mile
V.I. 20'
Fig. V.

To determine how much of the ground line A B C is visible from A.

The 500 feet contour, being the lowest contour to be considered in this problem, will be the datum plane.

Dot in the elevations of contours to the right and left of the datum contour as in the previous problem, and draw lines tangent to points of obstruction as at X and b.

It is obvious that those portions, A X, Y B and Z C of the ground line A C are visible from A.

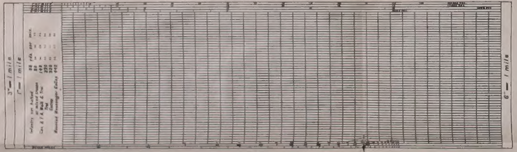
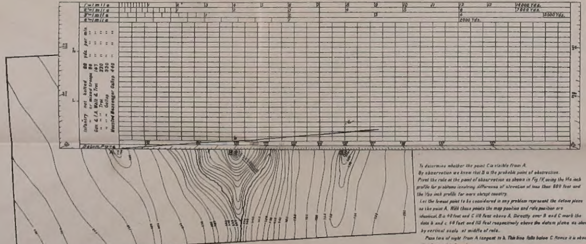


Fig. II.



Scale 3" 1 mile
V.I. 20'
Fig. IV.

To determine whether the point C is visible from A.

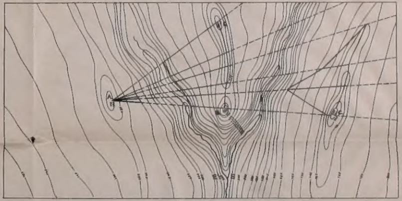
By observation we know that B is the probable point of obstruction.

Pivot the rule at the point of observation as shown in Fig. IV, using the 1/16 inch profile for problems involving difference of elevation of less than 600 feet and the 1/32 inch profile for more abrupt country.

Let the lowest point to be considered in any problem represent the datum plane as the point A. With these points the map position and rule position are identical. B is 40 feet and C 118 feet above A. Directly over B and C mark the dots b and c 40 feet and 115 feet respectively above the datum plane as shown by vertical scale at middle of rule.

Pass line of sight from A tangent to b. This line falls below C. Hence it is obvious that C is visible from A.

(The vertical scale at middle of rule should be interpolated in pencil according to contour interval of the map.)



Scale 3" 1 mile
V.I. 20'
Fig. VI.

To determine what portions of the area included within the lines D A B C are visible from A. Simply determine the visible portions of several ground lines between B and D by the same method used in Fig. V. Connect the extremities of the unbroken lines and the area visible from A is indicated within the unbroken lines. In case of forest cover at any point of obstruction the estimated height of the trees may be added.